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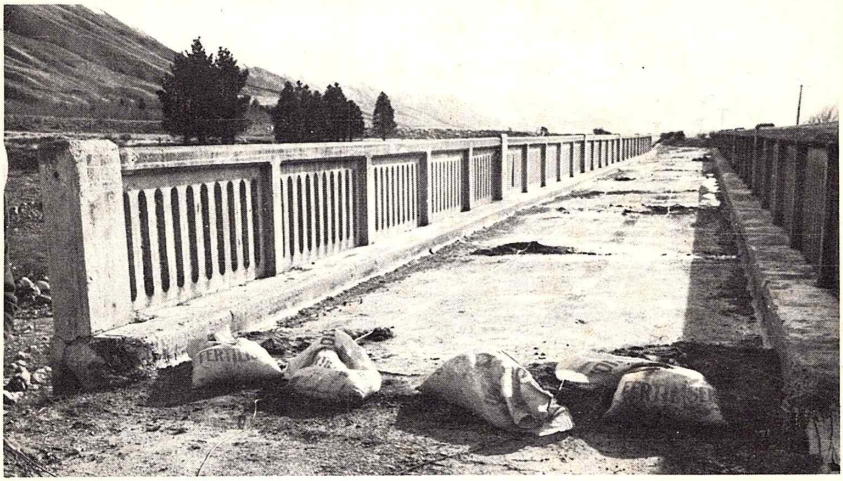

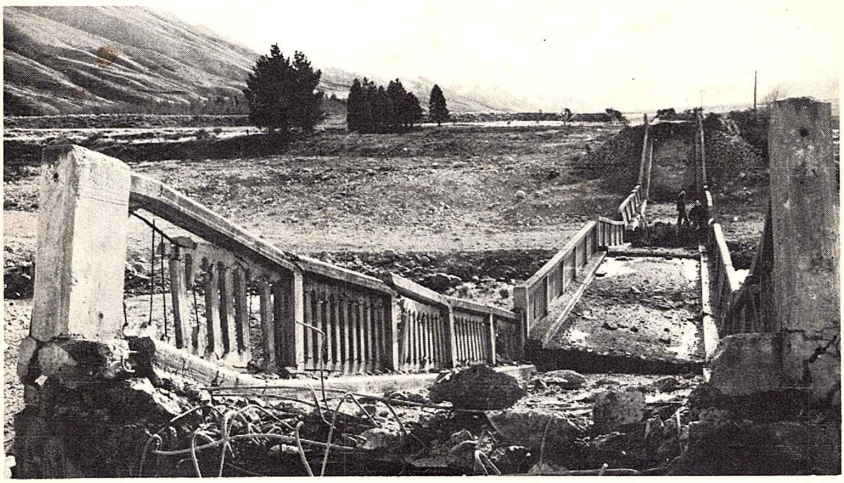

SAFETY IN CONSTRUCTION

No. 4

BLASTING CODE

Safety in Construction No. 4

CODE OF PRACTICE FOR CONSTRUCTION BLASTING SAFETY

on

Construction Work Under the Construction Act 1959

Prepared in the Office of the Chief Safety Engineer,
Department of Labour

1963

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FOREWORD

The use of explosives in construction work is both an art and a science.

It is a practical art in that it takes many years of experience to appreciate fully the finer points of handling and usage. As a science it requires considerable engineering knowledge of explosives and their effect on a variety of materials.

Since 1963 the *Blasting Code* has been a valuable reference book for certificated construction blasters, as well as providing assistance for candidates who are preparing for the construction blasters' examination.

Metrication and revision of this code has been jointly carried out by representatives from the construction industry and departmental officers.

G. L. JACKSON,
Secretary of Labour.

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GLOSSARY

ACT: Construction Act 1959.
AN: Ammonium nitrate.
ANFO: Ammonium nitrate fuel oil.
ASA: Lead azide, lead styphnate and aluminium powder.
AUTHORISED EXPLOSIVES: Explosives approved by the Chief Inspector of Explosives.
BAILEE: A person or organisation who takes delivery of goods for some purpose upon a contract, express or implied, that after the purpose has been fulfilled they shall be redelivered to the bailor or otherwise dealt with according to his directions or kept till he reclaims them.
BAILOR: One who entrusts goods.
BLASTING POWDER: A low VOD explosive initiated by safety fuse.
CIRCUITS: Electric wiring circuits used in electric initiation of explosives.
CODE OF PRACTICE: Means a recommended practice; and includes a description of any commodity, process, or practice, by reference to its nature, quality, strength, purity, composition, quantity, dimensions, weight, grade, durability, origin, age, or other characteristics; and also includes a glossary of terms, definitions, or symbols.
COLLAR: The mouth or start of a borehole.
CONSTRUCTION BLASTER: A person who holds a certificate of competency as a construction blaster.
DETONATING FUSE: A round cord containing a core of high explosive (P.E.T.N.).
ELECTRIC DETONATORS: Similar to plain detonators except that a fusehead with an electrical means of initiation is crimped into the otherwise open end.
EXPLODER: A device that when activated produces an electric firing current.
FIRING CABLE: A twin-core insulated conductor wire, used to connect an electric firing circuit to an exploder.
GELATINES: Dynamites or gelignites.
HIGH EXPLOSIVE: An explosive having a VOD of 1500 m/s or more.
INITIATION: The originating action that transforms an explosive into an explosion.
INITIATING EXPLOSIVES: The explosives contained in detonators (Blasting Caps U.S.A.).
LOW EXPLOSIVE: An explosive having a VOD of less than 1500 m/s. Blasting powder is a low explosive.
MAGAZINE: Locked storage for explosives and detonators.
MUST: Must is mandatory and SHALL has the same meaning.
NOTIFIABLE: Notifiable within the meaning of regulation 5.
N.Z.S. 4403:1976: New Zealand Standard, Code of Practice for the *Storage, Handling, and Use of Explosives (Explosives Code).*
OHMMETER: An electrical instrument used for testing electrical circuits.
PARTICLE VELOCITY: Particle velocity is the maximum particle velocity measured in any one of three mutually perpendicular directions, using an instrument of the approved type.

P.E.T.N.: Penta-erythritol-tetra-nitrate.

PLAIN DETONATORS: Small diameter tubes closed at one end and containing a small quantity of highly volatile explosive compound (ASA and PETN).

PRIMER: A cartridge of high explosive into which a detonator or detonating fuse has been inserted or attached.

REGULATIONS: Construction Regulations 1961.

SAFETY FUSE: A round cord containing a core of potassium nitrate black powder.

SAFETY INSPECTOR: An officer of the Department of Labour appointed under section 5 of the Act.

SAFETY SUPERVISOR: A person who holds a certificate of competency as a safety supervisor.

SHELF LIFE: The period of time from date of manufacture that explosives or detonators may be used safely.

STEMMING: Material used to plug a borehole from the collar to the explosive.

STORAGE: Duration of more than a working day.

TEMPORARY STORAGE: Short-term custody only.

VOD: Velocity of detonation.

PART 1

INTRODUCTION

1.1 Purpose

The purpose of this code is to provide in permanent form information on the safe use of explosives for persons engaged in the use of explosives on construction work. The information is not written to cover the detailed practical work of the construction blaster or others who carry out the actual work in preparing and laying the explosive charges. Detailed knowledge of the use of explosives should be obtained by working under an experienced construction blaster and from authoritative publications.

1.2 Construction Act 1959

The aim of this legislation is to make better provision for the safety and welfare of persons engaged on construction work. Provisions of this Act or any regulations under the Act relating to the safety of workmen employed in construction work shall apply also to the safety of persons lawfully in the vicinity of the work whether or not they are employed in the work. Employers must ensure that the provisions of the Act are duly and faithfully complied with and workmen employed by employers must comply with any instruction given them for the purpose of securing the observance of this Act or regulations, and any person who fails to observe the provisions of the Act or any Regulation commits an offence against the Act.

1.3 The Construction Regulations 1961

Regulations are the detailed requirements of the Act and cover the various aspects of construction work, certificates of competency, health and welfare, general safety provisions, scaffolding, excavations, power tools, blasting, ladders, gas supply safety, underwater works in compressed air, fire protection of construction work and demolitions.

1.4 Construction Work

Construction work as defined by the Act covers a wide range of buildings and engineering work, including site preparation, maintenance or demolition. Areas where explosives are most likely to be used are civil engineering projects, roadways, harbour works and site preparation.

1.5 Safety Inspectors

Safety inspectors of the Department of Labour are appointed to promote the safety and welfare of workmen engaged in construction work, to advise employers of workmen as to safe practices recommended in respect of construction work, to ensure that the provisions of the Construction Act and regulations hereunder are complied with, to investigate accidents occurring in respect of construction work, and generally take all such steps as may be desirable to prevent or limit the occurrence or repetition of accidents in construction work.

1.6 Directions and Orders

Safety inspectors may give directions to the employer or his representatives to institute safe practices on construction work. If it appears to the inspector that the work is being carried out in such a manner as to be dangerous to any workmen he shall give to the employer or his representative for the work such direction in writing as he thinks necessary to prevent an accident, and may at the same time or subsequently, order any persons to cease forthwith such work till the directions have been complied with.

1.7 Notifiable Construction Work

Certain construction work because of its more hazardous nature to workmen has been defined as notifiable construction work. One class of notifiable work is that in which explosives are used or are kept on the site for the purpose of being used.

Notification forms are obtainable from Department of Labour offices throughout New Zealand. The notification must contain a description of the work, the site of the work, name and address of the employer, name and certificate number of the appointed safety supervisor, the construction blaster's name and certificate number and the due date of commencement and estimated time of completion of the work. The notification must be dated, signed, and handed into the department not later than 24 hours before it is intended to commence the work.

1.8 Safety Supervisor

The safety supervisor must be the holder of a certificate of competency issued in respect of the kind or class of work he is supervising. His responsibility is to ensure that the provisions of the Construction Act and regulations thereunder are complied with in respect of the work he has been appointed to.

1.9 An Employer

An employer in relation to any construction work, means any person who is liable for the payment of wages of men employed on the work or would be so liable if men were so employed, and in respect of the operation of the mechanical plant, includes a bailee notwithstanding that the bailee is not liable for the payment of wages of the plant's operator.

1.10 An Employer's Responsibility

The employer has a responsibility as regards the use of explosives to:

(a) Supervise adequately all phases of the work including the use of explosives, and ensure that all statutory requirements are complied with.

(b) Take all reasonable precautions and ensure the safety of workmen and, for persons lawfully in the vicinity of the work, whether or not they are employed on the work, as well as property and services above and below ground, as well as persons lawfully in the vicinity.

1.11 Workman

Workman means any person engaged in any capacity in construction work, and includes an apprentice, and an employer when engaged in the performance of any such work. This includes an employer working on his own account and employing no workmen.

1.12 Workman's Responsibility

Every workman who fails to comply with any requirement under the Construction Act and regulations, or who does anything likely to endanger himself or others and, in the case of the use of explosives, endangers property of any kind above or below ground level, or disregards any instruction given him for the purpose of securing observance of the Act and regulations commits an offence against the Act.

1.13 Construction Blaster

The construction blaster is a person who has satisfied the Chief Safety Engineer that he has had adequate experience in the preparation, charging, tamping, and firing of explosives, and suitable experience in blasting operations on construction work. He must have a thorough knowledge of safe practices in blasting, and of the provisions of the Act and regulations as far as these provisions apply to construction work involving blasting operations. He must also pass any tests and examinations set by the examiners.

1.14 Examination Subjects for Construction Blasters

Examinations are related to:

(a) The types and classification of explosives and their strength and uses.

(b) The use of safety fuse, primers, electric firing, detonating fuse, and accessories, and the laying of charges preparatory to blasting.

(c) Safety precautions in blasting operations, including the protection and warning of the public, the protection of property, system and order for control of fly rock, precautions in respect of electrical firing, and misfire procedures.

(d) Secondary blasting, popping, cutting, and demolitions.

(e) The storage and handling and destruction of explosives detonator and fuses.

(f) The enactments of New Zealand relating to explosives.

1.15 Construction Blaster's Responsibility

The construction blaster must ensure that sound and accepted practices are followed in respect of:

(a) The selection and use of explosives, detonators, fuse, as suitable for the purpose for which they are being used.

(b) The handling, holding, and storage of explosives and accessories on the site of the construction work.

(c) The lay-out of the blast and the preparation, charging, and tamping of shots.

(d) The connection and testing of lines and circuits.

(e) The prevention of undue scatter and damage to property.

(f) The procedure in cases of misfire and the disposal of surplus or unused explosives, detonators, and fuse.

1.16 **Safety Supervisor**

The safety supervisor is the employer or the employer's representative who holds a certificate of competency as a safety supervisor applicable to the class of work being carried out and who has been appointed as safety supervisor for that work.

1.17 **Safety Supervisor's Responsibility**

The safety supervisor on any construction work in which blasting operations are carried out shall ensure that:

(a) Only the holder of a certificate of competency as a construction blaster is employed in the preparation and laying of charges ready for firing.

(b) All practical steps have been taken to guard against danger to persons and property in the vicinity of the blast.

(c) Proper warning signals are given before the blast and all clear signals after the blast.

(d) Explosives, detonators, and fuses are at all times under proper care and custody and, when not in use, are returned to an explosives magazine or placed in a securely locked storage place on the site of the work.

(e) Blasts are fired only when all practical steps have been taken to clear the danger area.

(f) The agreed all-clear signal is given after the blaster and the safety supervisor have taken all practical steps to ascertain that conditions are safe at the site.

(g) The provisions of this code relating to safety in blasting operations and construction work are complied with. The construction blaster may be the safety supervisor provided he holds a certificate of competency as a safety supervisor.

1.18 **Safe Handling, Carriage, and Storage Responsibility**

The construction blaster, the safety supervisor and the employer must ensure that the following rules with regard to the handling, carriage, holding and storage of explosives and detonators on and in the vicinity of the construction work are observed:

(a) Only sufficient quantities of explosives and detonators for daily use shall be brought to the immediate vicinity of the blasting operations.

(b) Detonators and explosives shall at all times be kept in separate locked containers and kept apart until the final stages are reached for making up the charge ready for firing.

(c) Explosives, detonators and fuse shall be suitably protected from the weather, kept at safe distance from vehicular and pedestrian traffic, and from mechanical, physical, and electrical hazards.

(d) All practical precautions shall be taken in the care and custody of detonators and explosives particularly when in open lots and not in the original containers, to avoid unauthorised interference or access by unauthorised persons. The permanent storage of over 5 kg of explosives and the carriage off the job of more than 50 kg of explosives requires a licence from the Chief Inspector of Explosives. The temporary storage, carriage, and handling in the vicinity of a construction work site must be in accordance with the rules and safe practices set out in this Blasting Code.

1.19 **Safety Requirements**

No person shall, on construction work:

(a) Knowingly cause or allow to be used or use in blasting operations any explosive or accessory which is defective or deteriorated to such an extent as to create a danger; or

(b) Omit to check that any explosive or accessory used in blasting operations is fit for use before using it; or

(c) Cause or allow to be prepared or prepare blasting charges in such a manner as to create a danger; or

(d) After firing a charge fail to take proper steps to check that all explosives contained in the charge have exploded, or leave unexploded explosives in such a position or condition as to create a danger; or

(e) Leave or cause to be left any explosive or detonator in an insecure or abandoned condition or cause to be abandoned any explosive or detonator.

1.20 **Authorised Explosives**

Only approved explosives may be used on construction work, and the characteristics of the explosive used must be fully known to the construction blaster. It must be an authorised explosive in accordance with the Explosives Act 1957 and Explosives Regulations 1959.

1.21 **General Safety**

Smoking or the use of naked flames shall not be permitted within 15 m of where the explosives are being handled or stored.

PART 2

EXPLOSIVES AND THEIR DESCRIPTION

2.1 Definition of an Explosive

The essential characteristic of all explosives is that on initiation they react suddenly to form large volumes of gases at high temperatures, and the almost instantaneous release of these gases creates very high pressures. This reaction proceeds very rapidly and continues throughout the mass of the explosive once initiated at any point within it. Within the explosion there are several important characteristics. One is the VOD which is a measure, in metres per second, of the speed at which the detonation wave travels through a column of explosives. Another is the energy released which, while acting equally in all directions, tends to take the path of least resistance.

2.2 Main Types of Explosives

Explosives used in construction work fall into three main types:

(a) *High Explosives*—These explosives have a velocity of detonation of not less than 1500 m/s. They produce large volumes of gas and considerable heat at extremely high pressures. The reaction is started and sustained by a shockwave initiated by a detonator or detonating fuse. In the first action the shockwave developed in the explosive is transmitted into and causes fractures in the rock or other medium being blasted and this action is followed by the high pressure gases which complete the destruction. The energy released acts equally in all directions but naturally tends to escape through the path of least resistance. In this respect all explosives act in exactly the same manner. Therefore, irrespective of what type or grade of explosive is used, the hole spacing, loading, and tamping must be carried out very carefully so that the gases will be confined in such a manner that they are forced to do useful work before they can escape.

(b) *Low Explosives*—These are explosives with a VOD of less than 1500 m/s, produce a heaving action rather than a shockwave. They can be initiated by a spark or flame and because of this are especially dangerous.

(c) *Initiating Explosives*—These are extremely sensitive and are only used in small quantities in detonators. Because they do not produce large volumes of gas they are unsuitable for use as high explosives but are ideal for initiating the shockwave in high explosives.

2.3 Classification of High Explosives

Explosives used on construction work fall into three main groups; these are:

(a) Gelatines are usually manufactured and sold in cartridge form with the characteristics of plasticity, high density, and water resistance.

Blasting gelatine was the first invented and was obtained by the addition of about 8 percent nitro cotton to nitro-glycerine. Because nitro-glycerine freezes at low temperatures the gelatines were dangerous to use in low temperatures. To overcome this a percentage of nitro-glycerine is replaced by nitrated glycol which is very similar to nitro-glycerine but has a much lower freezing temperature. The explosives so treated are known as polar types and are safe to use in the most extreme weather conditions likely to be found anywhere in New Zealand.

(b) Non-gelatines, are usually of a powder or granular form, sometimes made into cartridges and are more sensitive to the action of moisture than the gelatine series of explosives.

(c) *Slurry Blasting Agents*—These are explosives which consist of ammonium nitrate, sodium nitrate, sugar or starch, water, and other ingredients which cross link and gell and give the slurry its power as an explosive.

2.4 **Commercial Explosives**

Most commercial high explosives used in New Zealand contain some nitro-glycerine. Nitro-glycerine, in its free state is a yellowish, oily, transparent liquid and is a very powerful and unstable explosive. As a liquid it is too unstable and sensitive to be handled safely and is therefore converted into a more convenient and stable form by the addition of various absorbent additives.

2.5 **AN Explosives**

Ammonium nitrate (AN) based explosives have a higher strength, and VOD than sodium nitrate (SN) explosives, but are more susceptible to moisture. Explosives used on construction work in New Zealand are mostly ammonium nitrate based compositions.

2.6 **Ammonium Nitrate Carbonaceous Blasting Agent**

The most common of these is ammonium nitrate fuel oil (ANFO) which must not be confused with the AN Explosives mentioned above. The use of ANFO is increasing. Manufacture of ANFO is unlawful except when carried out in accordance with the provisions of the Explosive Regulations 1959 and the written approval of the Chief Inspector of Explosives.

2.7 **Strength of Explosives**

The weight strength is the strength of an explosive compared with that of an equal weight of blasting or (TNT) the strongest commercial explosive.

Weight strength which is taken as 100 is determined by detonating a 10 gram charge of explosives in a ballistic mortar and comparing the resultant recoil with the same weight of blasting gelatine or TNT.

Simple strength ratios between explosives containing different chemical components do not exist, therefore manufacturer's specification of strength, must be obtained before unknown explosive types are used.

2.8 **Wrapper Terminology**

The words and figures on wrappers, packages, or cases refer to the grade and type of explosive and not the strength. Nonetheless, there is a relation between the numerals identifying SN and AN explosives. For example: SN Gelignite 60 percent indicates a sodium nitrate gelignite containing 60 percent nitro-glycerine while AN gelignite "60" (note the inverted commas) is an ammonium nitrate gelignite having a strength equal to SN 60 percent.

In other words SN explosives are designated by the percentage of actual nitro-glycerine they contain, while AN explosives are designated by a figure in inverted commas which is equivalent in strength to the nitro-glycerine percentage in SN explosives.

2.9 **Comparison of Explosives**

As a guide to construction blasters, general characteristics of explosives used on construction work are given so that comparisons may be made. Black powder or blasting powder does not have a true VOD as detonating explosives here. Its rate of burning is affected by confinement. In the open, chains of black powder burn relatively slowly and are measurable in seconds per meter. Confined in steel pipes the speed of explosives have been timed at speeds from 170 m/s for very coarse granulations to 630 m/s for finer granulations. As blasting powder has very poor water resistance it is best suited as a heaving explosive in dry situations. Gelatines have a VOD ranging from 2400 m/s for 25 mm diameter cartridges and is increased as the diameter of cartridge increases up to 100 mm however, over this diameter little increase in velocity is achieved. Both dynamite and gelignite have reasonable water resistance and are best suited for use on material where a quick shattering action is required.

2.10 **Plaster Charges**

These are explosive charges that are placed against the material to be blasted rather than inside it. An essential characteristic of plaster explosive is that, it must have a high VOD. Two examples are ICI's "plastergel" and Dupont's high velocity gelatine both of which have a VOD of between 5100-6700 m/s.

2.11 **Granular Explosives**

Simple granular explosives (ANFO) have very poor water resistance, therefore must only be used in dry situations unless packed into water tight containers. Because their VOD is from 2300–3000 m/s they are ideally suited for work of a heaving rather than splitting nature. Generally, granular explosives require a booster to initiate, however, specially developed varieties, with a higher VOD and detonator sensitivity are produced.

2.12 **Sheet Explosive**

This is a high velocity explosive having a VOD of 6800 to 7500 m/s with excellent water resistant qualities. It is a specialist explosive used for harden-

ing and cutting steel. Dupont's "Detasheet" and ICI "Metabel" are two examples of this type of explosive.

2.13 **Underwater Explosives**

Because of the environment, special characteristics are needed. Explosives for underwater use should have high bulk strength and good water resistance, and maintain their sensitivity when subjected to water pressures. Examples are Dupont's "High Velocity Gelatine" and ICI "ANGD 95", "Plastergel", "Hydrogel", or "Geophex".

2.14 **Sizes of Explosives**

Explosives are usually packed in cartridges that vary in diameter from 20 mm upwards and range in length from 150 mm to 1 metre or more. Generally they are bulk packed in 25 kg cartons. Provided storage is good, deterioration is negligible while the cartons are sealed and the liners kept intact. After breaking open the bulk carton always reseal the polythene liner bag. Small quantities, even for use the same day, should be kept in closed air tight polythene bags prior to use.

2.15 **Life of Explosives**

Explosives have a varying life span which is termed shelf life. This information is available from the manufacturer on request. Always use the oldest explosives first and never use explosives if the shelf life has expired or there are signs of deterioration.

All explosives used on construction work must have the date of manufacture displayed on the outer package.

2.16 **Choice of Cartridge Size**

The hole should be made to fit the cartridge, **not** the cartridge to fit the hole. The cartridge must be able to be freely inserted to the bottom of the hole without either ramming or unwrapping. The diameter of the hole must be at least 6 mm larger for cartridges up to 35 mm diameter and at least 10 mm larger for cartridges of greater diameter.

2.17 **Health Hazards**

Some explosives can be injurious to health if not handled and/or stored correctly. At best they may only cause severe headaches at the worst they can be poisonous. In confined spaces the fumes from explosions must be dispersed or blown out before re-entering the blast area. A suitable treatment for nausea or illness from the effects of explosive gases is to treat the patient with a spoonful of treacle or a cup of very sweet tea. In extreme cases the person affected should be made to consult a doctor immediately.

2.18 **Special Explosives**

Whenever special explosives are required the construction blaster should contact the manufacturer for advice on the correct methods for their use and any special precautions to be taken.

PART 3

DETONATION OF EXPLOSIVES

3.1 Initiation of Explosives

All explosives, with the exception of blasting powder, require a detonating agent to initiate the blast. Blasting powder or black powder, because it can be easily initiated, is probably the most potentially dangerous commercial explosive used today and should always be handled, stored and used with great care.

3.2 Firing of Blasting Powder

Blasting powder is obtainable in granular or powder form. The normal method of initiating is by using safety fuse with a minimum length of 1 metre. It is a low explosive and therefore good tamping is essential so that its full potential is attained. As it is readily initiated by sparks or flames, it must never be handled near any heat source.

3.3 Performance of High Explosives

This depends on the VOD, density, water resistance, strength and stability of the explosive, the type of material to be broken up and the stemming and tamping of the charge.

3.4 Firing of Gelatinous Explosives

These are all initiated by means of a detonator or detonating fuse.

3.5 Firing of ANFO

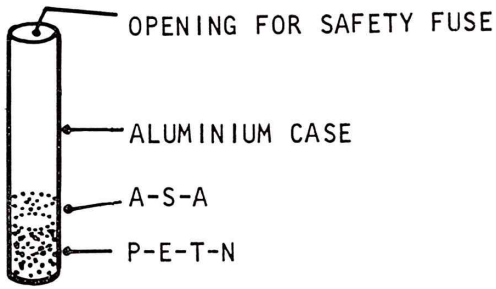
ANFO is initiated by means of a booster made up of a detonator and an explosive cartridge, or by the use of detonating fuse and a cartridge of explosive.

3.6 Plain Detonators

Plain detonators are used for general purpose work of up to 6 separate charges at one time. For their use on construction work approval must be obtained in writing from a safety inspector.

To activate a plain detonator, at least 1 m of safety fuse is inserted into the open end of the detonator as far as it will go, and held there by crimping the mouth of the tube with approved crimping pliers. The use of a tool other than an approved detonator crimper is a dangerous practice and, therefore, not acceptable. Plain detonators must be kept dry, for if they become damp or oily they may fail to function. To provide water-proofing to a plain detonator after crimping, smear the crimped end and

safety fuse with an approved waterproofing compound. All detonators are sensitive to shock and any sawdust or debris in the tube of a plain detonator must be tapped out on the construction blaster's thumbnail before the safety fuse is inserted, never blow out the obstruction or remove it with a nail or implement.



PLAIN DETONATOR

3.7 **Safety Fuse**

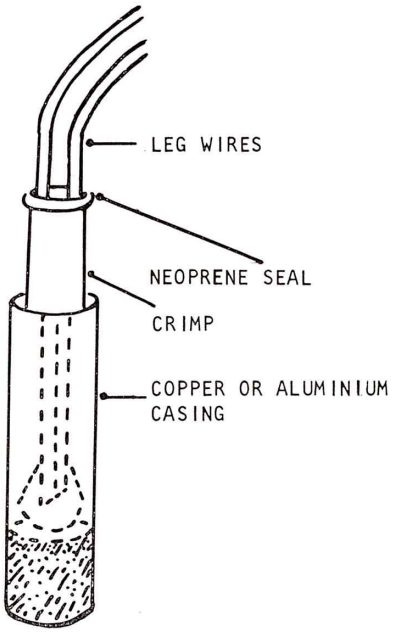
Safety fuse comes in a variety of colours and outer coverings. Selection for use on construction work is dictated by the fuse being in good order and condition, and having a burning speed of 100 seconds plus or minus 10 seconds per metre. Safety fuse is used to initiate blasting powder and when fitted with a plain detonator, it is used to initiate high explosives or detonating fuse. Safety fuse has a very limited life span under water or in positions of heat, therefore it should not be used in either situation or stored in heated storage. If the outer covering of the fuse shows signs of bitumen weeping or is cracked, do not use it.

3.8 **Electric Detonators**

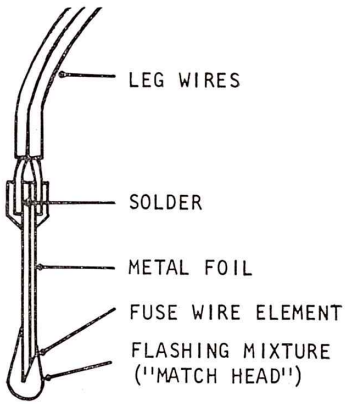
Electric detonators are similar to plain detonators as far as the explosive content is concerned. Initiation of the detonator is by an electric current passing through an element in the fuse head which ignites the fuse head composition that in turn initiates the ASA and P.E.T.N. Electric detonators have a decided advantage over plain detonators in that the explosive within the detonator is shielded from the elements and other forms of accidental ignition by the sealing and crimping of the casing around the leg wires.

Except when the detonator is being tested for continuity and resistance and when joining to the firing cable or blasting circuit the ends of the leg wires must be joined together (shorted out) to form a complete closed electronic circuit.

Inset 1*



ELECTRIC DETONATOR



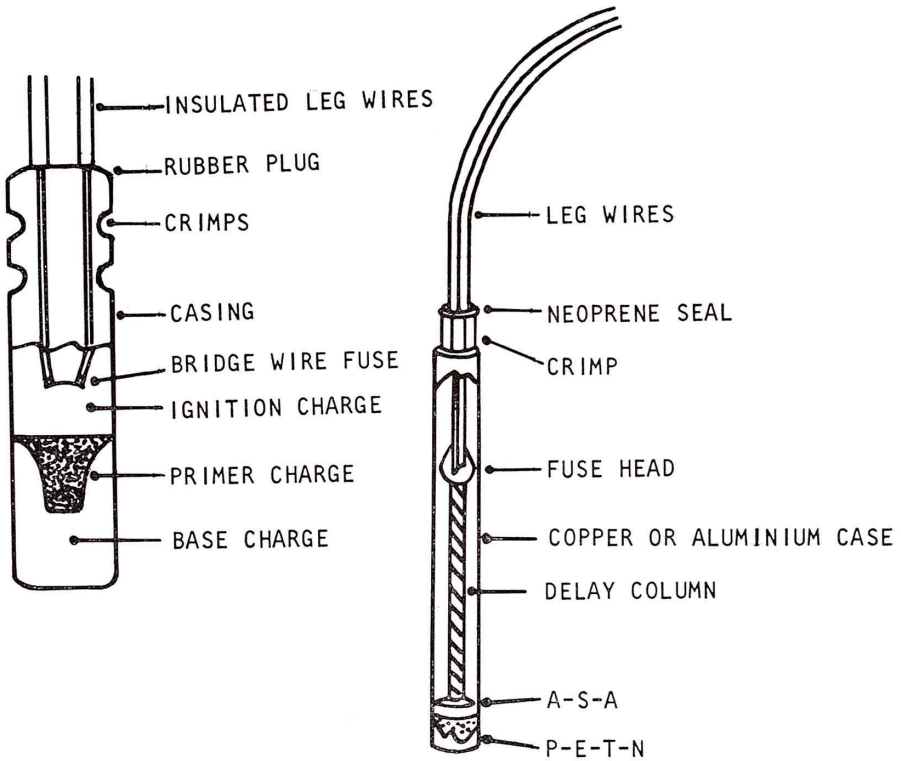
FUSE HEAD OF AN ELECTRIC DETONATOR

3.9 **Electric Delay Detonators**

In delay detonators the explosive charge is the same as in instantaneous detonators but instead of the match head initiating the explosive it initiates the delay column which in turn initiates the explosive.

The length of delay is governed by the length of the delay column within the detonator, therefore the length of detonator tubing will increase as the delay increases.

Indication of delay times are by numbered tags on one leg wire or numbers on the base of the detonator. Never use delay detonators of different manufacture in the same circuit, because their electrical characteristics are different.



CUT-AWAY VIEW OF ELECTRIC DELAY DETONATORS

3.10 **Submarine Detonators**

Submarine detonators should always be used for underwater work, because they have been specially sealed to withstand water pressure and have greater power to function satisfactorily under increased pressure due to the head of water.

3.11 **Detonating Fuse**

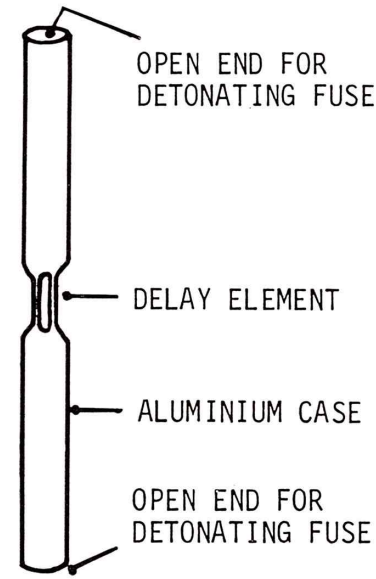
Detonating fuse consists of a core of P.E.T.N. enclosed in flexible tubular outer covering. Although the name implies that the fuse is a detonator it is in fact a tube of high VOD explosive and needs a detonator to initiate it. Because the explosive chain of P.E.T.N. in the detonating fuse has a VOD of 6400–7000 m/s, it can be used to convey the detonating wave from the detonator to the explosive charge or charges. This permits the placing of detonators outside the borehole and in a position for easy removal

should the situation so demand. Detonating fuse can be used to connect any number of charges, all of which can be initiated by one detonator. Detonating fuse can be identified by the colour and texture of the casing. Standard fuse has 10 grams of P.E.T.N. per metre. Fuse containing less is available.

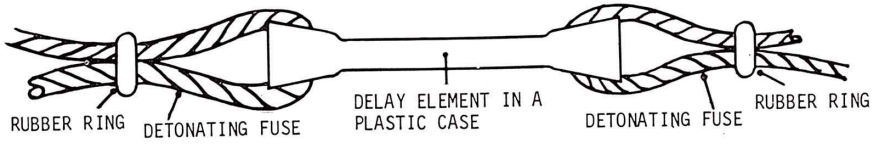
This lighter detonating fuse is used with advantage for branch lines on the surface because it has a lower noise level when detonated. For underwater work, fuse with a wear resistant outer casing and explosive strength greater than standard fuse should be used, the fuse ends should also be sealed against the ingress of water. Detonating fuse generates a lot of noise when detonated on the surface. This can be reduced considerably by covering the fuse with at least 150 mm of sand. Care should be taken to use sand that is free from stones or other material that could become projectiles when the fuse is detonated.

3.12 **Detonating Fuse Relays**

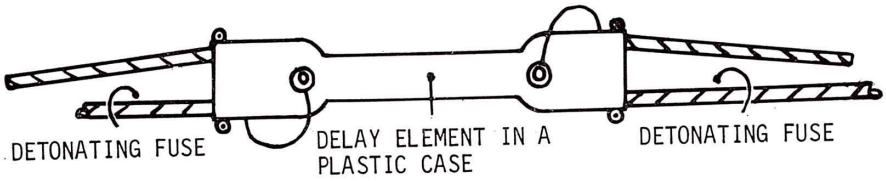
Detonating fuse relays are used to place time delays in the detonating fuse line. They are manufactured with several delay periods and may be likened to a plain detonator except that they are open at each end for insertion with a delay element in the centre of the detonating fuse. In use it is inserted into a detonating fuse main or branch line wherever a delay interval is required. The detonating fuse is cut and, just before firing, the



DETONATING FUSE RELAY



DETONATING RELAY CONNECTOR



M S CONNECTOR

TYPES OF DETONATING FUSE DELAY CONNECTORS

relay is connected into the line by inserting the cut ends of the line into the open ends of the relay and crimping tight, using detonator crimpers.

Generally in plastic relays the detonating fuse is held in position with rubber rings or tapered pegs. Never use detonating relays in situations that are damp, or when rain or even light rain is falling, as the open ends of the relay give very little protection to the fine columns of delay element within the relay and dampness can cause a misfire. Because the delay element has a limited shelf life, even when stored under the best of conditions, after 3 years from the date of manufacture, a few should be test-fired before use to ensure that the delay time is still accurate.

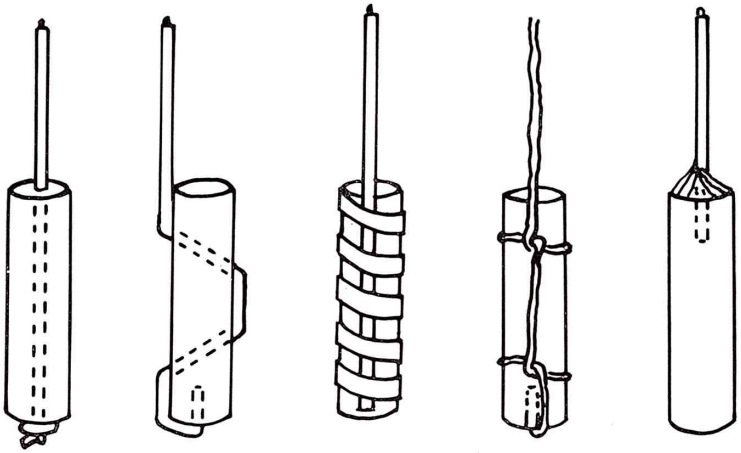
PART 4

PRIMERS AND FIRING

4.1 **Primer**

A primer is a cartridge of high explosives into which has been inserted a detonator or detonating fuse and is used to detonate a column of explosives or an explosive charge.

A primer with safety fuse and plain detonator may be used on construction work where it can be established that the use of an electric detonator may cause a premature explosion due to the presence of extraneous electricity or where the safety inspector has authorised in writing the use of plain detonators.



DETONATING FUSE INITIATION

ELECTRIC DETONATOR INITIATION

PLAIN DETONATOR AND SAFETY FUSE INITIATION

ALL ARE PRIMERS

4.2 **Preparation of Capped Fuse**

This is the placing of safety fuse in a plain detonator. As the powder core can deteriorate or otherwise be harmed 25 mm should always be cut off to get a fresh end then:

(a) Cut off the length required with a square cut using a sharp knife or fuse cutters.

(b) Remove the detonator carefully from its container and then immediately close the container.

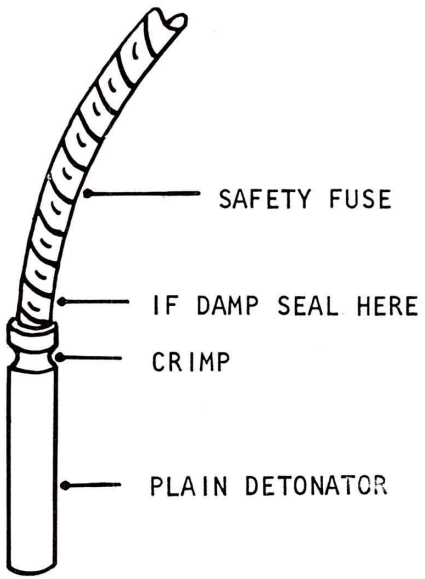
(c) Inspect the detonator for serviceability. Remove any foreign matter or material from it by tapping on a thumb nail or palm of the hand. Never attempt to remove any foreign material with a match stick or

similar object or attempt to blow it out. Never use a detonator that appears to be in poor condition or damaged, or from which debris cannot be removed by tapping; put it aside for disposal.

(d) Insert the fresh, squarely cut, end of the fuse into the detonator, so that the fuse and detonating compound are in contact.

(e) Gently but firmly crimp the detonator, about 4 mm from the mouth, to the fuse using approved crimping pliers.

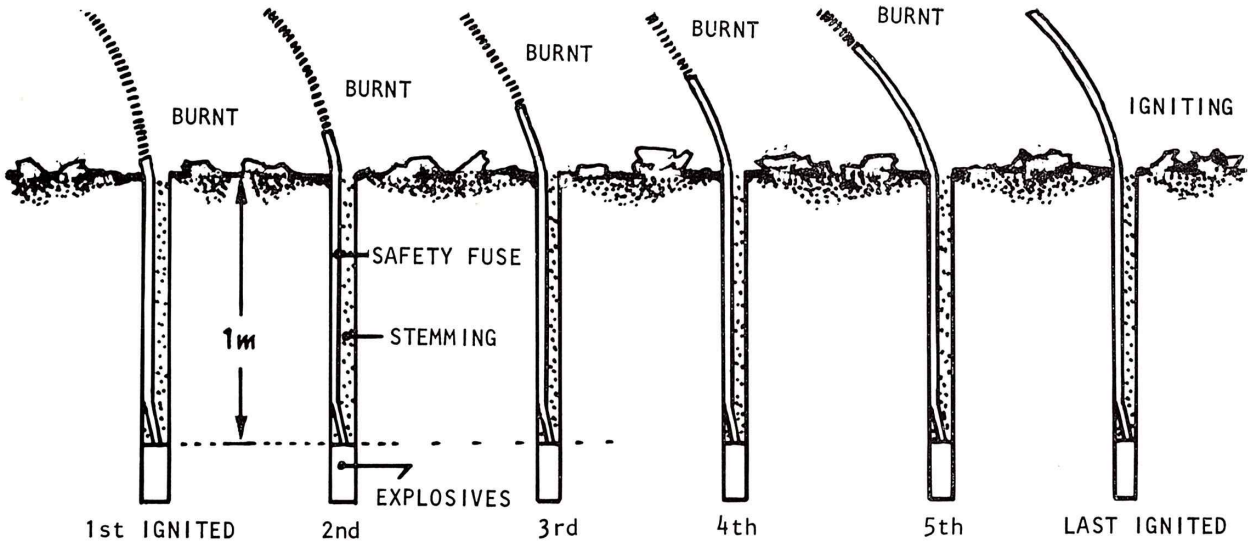
(f) Seal the junction of the fuse and detonator with approved waterproofing compound.



CAPPED FUSE

4.3 **Ignition of Safety Fuse**

Cut the end of the fuse with a sharp knife, to an angle of about 45 degrees and ignite by placing one or two match heads on the exposed powder train and striking across the matches with a match box. An alternative method is to split the fuse with a sharp knife for a distance of about 4 to 5 mm and then ignite as above. Either method is suitable for lighting one fuse but where more than one fuse is to be lit special fuse igniters must be used. The maximum number of fuses that may be lit at any one time is six. It must be remembered that, when lighting more than one fuse, the least amount of any fuse still to burn after the last fuse has been lit must be at least one metre long.



IGNITION SEQUENCE FOR A MAXIMUM OF SIX CAPPED FUSES

4.4 **Inserting the Capped Fuse into the Explosive**

(a) Take a cartridge of high explosives and open up the wrapper at one end.

(b) With a wooden skewer, make a hole in the end of the cartridge deep enough to take the full length of the detonator.

(c) Insert the detonator into the hole so that the detonator is completely contained in the cartridge. Replace the wrapping round the fuse, tie it with a piece of twine, binding wire, or insulation tape.

4.5 **Position of Primer and Charge**

When using safety fuse the primer is the last charge to be inserted in the hole. Never place it at the bottom or middle as the charge might be ignited by the burning fuse and this may cause a premature explosion. A kink in the fuse could lead to a misfire or a hangfire. It is safer, when using a capped fuse, to initiate the explosive with detonating fuse down line and tie the capped fuse to it at the mouth of the borehole.

4.6 **Electric Shot Firing**

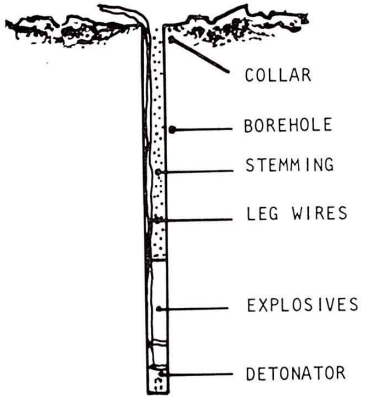
Because electric shot firing gives the construction blaster complete control over the time of initiation of the blast, only approved electric shot firing methods and instruments shall be used to initiate the blast. If due to extraneous electricity the use of electric detonation is dangerous, then safety fuse and plain detonator with or without detonating fuse may be used. If, in the opinion of a safety inspector, electric firing methods are impracticable, he may authorise, in writing, the use of a different method.

4.7 **Preparation of a Primer with an Electric Detonator**

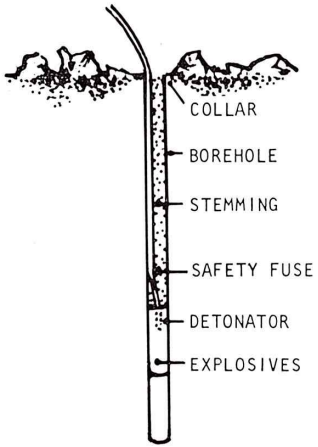
Make a hole at the end of the cartridge with a wooden or brass skewer and insert the detonator until it is completely buried, then make one or more half hitches round the cartridge with the detonator leg wires, ensuring that the ends are shorted out.

4.8 **Series Circuit**

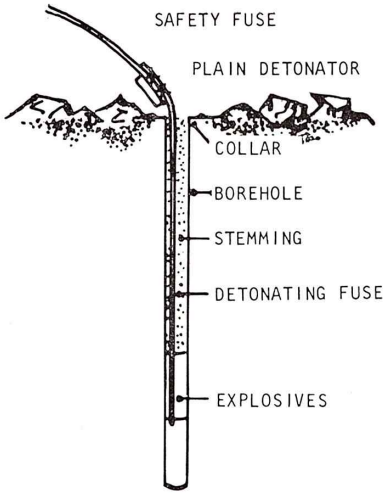
This is the circuit that is the simplest and safest to use, because the circuit tests are simple, and because, if there is any break in the circuit, none of the detonators will explode when the exploder is activated. Formation of a series circuit is by connecting one leg wire of a detonator to one leg wire of the next detonator and so on until all detonators have been joined, leaving one unconnected leg wire at each end, which are then connected to the two



POSITION FOR ELECTRIC DETONATOR

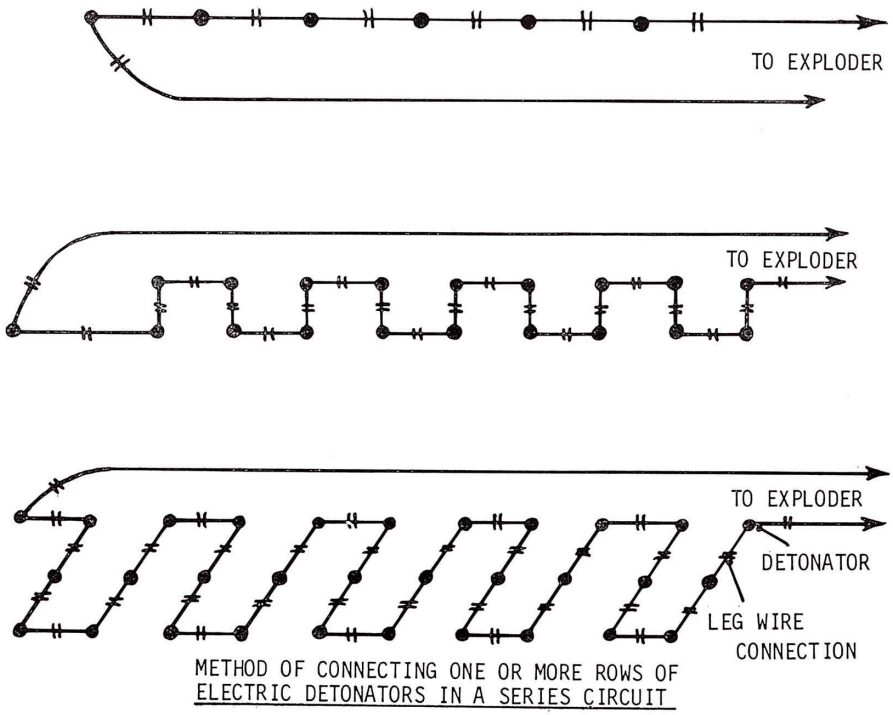


POSITION FOR CAPPED FUSE



CAPPED FUSE INITIATION WITH DETONATING FUSE

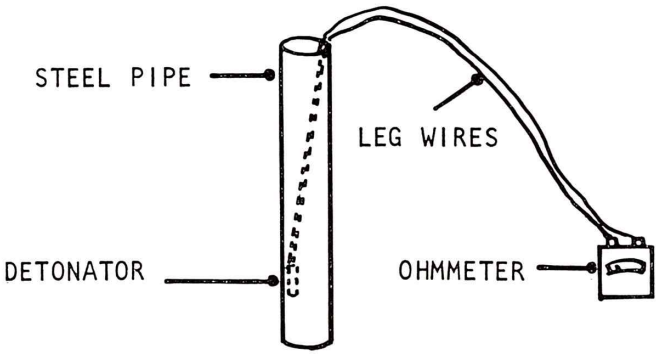
core firing cable, one to each wire. In a series circuit the sum of the resistance of each component contained in the circuit should equal the total resistance of the circuit.



METHOD OF CONNECTING ONE OR MORE ROWS OF ELECTRIC DETONATORS IN A SERIES CIRCUIT

4.9 **Testing of Electric Detonators**

Electric detonators should be tested for resistance and continuity prior to use. Instantaneous detonators having 2 m leg wires should have a resistance of between 1.0–2.1 ohms. The procedure for testing is, place the detonator into a length of steel pipe, not less than 700 mm long, and at least 35 mm inside diameter. (Standard steel scaffold tube is acceptable.) Undo the shorted leg wire ends and connect them to an approved ohmmeter. Carry out a resistance and continuity test, then rejoin the leg wires together (short out) and keep detonators of similar resistance together. Detonators the resistance of which is under 1.0 ohm or over 2.1 ohms, or with any other defect must be put to one side for disposal.



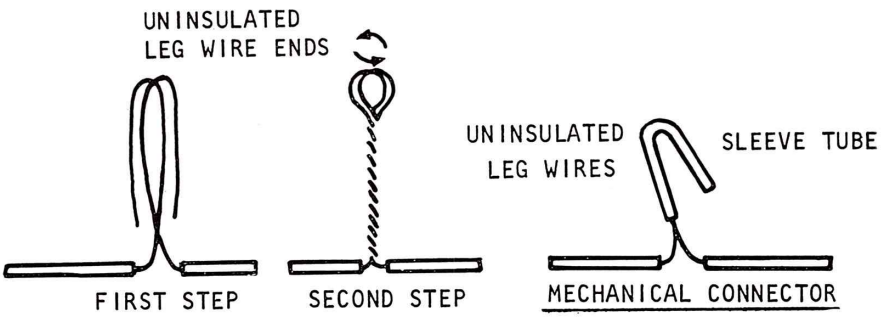
SET-UP FOR ELECTRIC DETONATOR TEST

4.10 **Ohmmeters**

Ohmmeters are instruments that measure the resistance in an electrical circuit and to obtain this measurement a small, but safe electric current is passed through the circuit. The safest test current to pass through an electric detonator would be none at all, but as this is not possible the smallest practical current has to be used. Therefore only ohmmeters that deliver not more than 10 milliamps, when short circuited across the terminals of the instrument, should be used. The scale of the instrument should be graduated to give clear readings from 0 ohm upwards and include an infinity reading.

4.11 **Connections and Firing Cable**

All connections of detonator leg wires to firing cables or connecting wires must be clean, insulated, and firmly twisted together. The twisted loop connection is ideally suited for this, as it gives good mechanical strength and



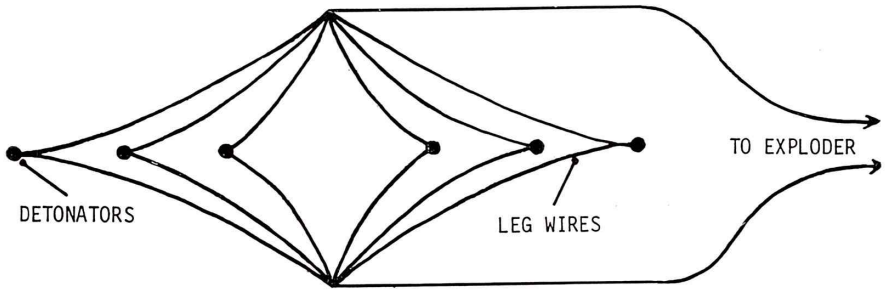
TWISTED LOOP CONNECTION

electrical contact. The loop should be squeezed together and the joint insulated with electrician's tape. To prevent leakage to earth, or short circuits, it is important that the insulation of all connections between detonator lead wires, firing cable, and any connecting wires, be sound and undamaged.

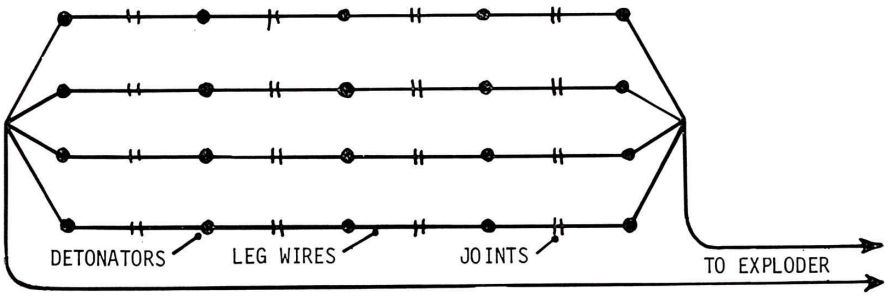
Irrespective of the conditions all connections must be insulated either with electrician's tape or some other satisfactory equivalent such as mechanical connectors. When the circuit has been completed, and before the firing cable has been connected to the exploder, a resistance and continuity test must be carried out at the firing point end. Never test the circuit at the detonator lead wires before the firing cable has been connected.

4.12 **Other Circuits**

Two alternative electric circuits, namely parallel and series parallel, can be used. Neither are generally recommended on construction work. There is also the possibility of one or more of the detonators not functioning while others in the circuit do so. If this occurred the Construction Blaster may be unaware of the unexploded detonators and explosives and endanger himself and possibly others by re-entering the area too soon (see 5.20 Electric Initiation Misfire).



A SIMPLE PARALLEL CIRCUIT



A SERIES PARALLEL OR SERIES-IN-PARALLEL CIRCUIT

4.13 **Exploders**

Only approved exploders shall be used and these shall be kept dry, safe from damage, and in good useable condition. The capacity of the exploder shall be clearly marked on it, giving the maximum number of detonators that can safely be initiated in a circuit having not more than "x" resistance. The construction blaster must not attempt to fire a circuit having a resistance greater than that marked on the exploder. At intervals, not exceeding 1 year, the exploder shall be serviced and tested, and a log book shall be maintained for each exploder, showing the result of the test and date of servicing which shall be available for inspection by a safety inspector.

4.14 **Locking of Exploders**

It shall be the duty of the certificated construction blaster to see that the exploder is inoperative for firing when not in use and the device used to render the exploder inoperative shall remain in his possession until the exploder has been returned to the store. In the case of small hand operated and hand held exploders the entire exploder **must** be kept on his person for safety.

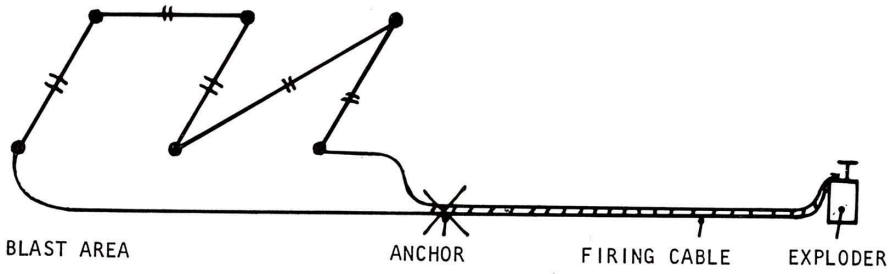
4.15 **Firing Cable**

The firing cable must be of good quality twin core, having low resistance and good insulation. It should also be wear and damage resistant. The cable should be in a twisted form, rather than two parallel straight wires. Commonly used cable in New Zealand has a resistance of up to 5.4 ohms per 100 m.

4.16 **Cable Testing**

Good testing procedure dictates that, before every blast, a test for insulation and continuity is performed. The insulation test is done by connecting an ohmmeter to the two wires at one end of the firing cable and separating the two wires at the other end. If the insulation is good, no current will flow, and the resistance will read infinity. The continuity test is the same as the insulation test except that the two separated wires at the other end of the cable are joined together. A reading on the ohmmeter indicates that the circuit is complete, and also gives the resistance in the circuit.

4.17 **Cable Anchoring**



CONNECTION FOR SERIES CIRCUIT PRIOR TO INITIATION

Before connecting the firing cable to the detonators, it should be anchored a few feet from the blast. This prevents the cable being flung into the air by the blast and possibly making contact with overhead or nearby live power lines.

4.18 **Cable Running**

Always run the cable from the blast area to the firing point, never the other way round. Always carry out tests of firing circuits after the cable has been run out and from the firing point end.

4.19 **Stemming**

This is the name given to the material which fills the hole to confine the explosives as tightly as possible. Materials recommended for use as stemming are as follows:

(a) Large diameter down holes; that is holes of 100 mm diameter or larger, 9–12 mm, all-in crushed stone.

(b) Small diameter down holes, that is holes of less than 100 mm diameter, 6 mm, all-in crushed stone or dry sand.

(c) Horizontal holes and small diameter up holes, a mixture of two parts moist sand to one part of clay. Alternatives are sand, screenings, or fine drill cuttings all wrapped in paper.

A mixture containing large rocks or stones that may result in fly rock shall not be used.

4.20 **Tamping**

With inverse or bottom initiation, such as is used in electric firing, the primer shall not be tamped. Tamping shall commence with the next cartridge inserted or, if none is inserted, shall commence at least after 150 mm of stemming has been put in. Tamping of cartridges shall be by means of firmly applied steady pressure. Tamping of top primers, shall not commence until at least 150 mm of stemming has been put in. Tamping of stemming material shall be light at first and pressure gradually increased as the hole becomes filled.

4.21 **Precautions During Tamping**

Care shall be taken to ensure that fuse or wires connected to the detonator are not damaged during the placing of stemming material and its tamping. In the case of safety fuse, the portion projecting from the hole shall not be coiled. In no case shall a fold or a coil of fuse be stuffed into the collar of the hole. If it is necessary to bend the safety fuse, it shall be done in the direction of the original coiling and to a radius of no less than 150 mm. In multiple firing separate fuses shall not be in contact, except in a multiple fuse igniter.

4.22 **Tamping Rods**

Only tamping rods of either wood or an approved non-metallic material such as plastic hose of suitable length shall be used. Ferrules, tips, or connectors made of metal shall not be used on tamping rods. When used for inserting the charge, the tamping rod shall be thoroughly cleaned of adhering grit and the working end shall be kept clean. Whenever the tamping rod is soiled with explosives, it shall be thoroughly cleaned by washing. As soon as the working end becomes worn, it shall be cleaned and cut off to reinstate a flat tamping end.

4.23 **Stemming of Underwater Charges**

In general no stemming is needed, unless the hole and the water are very shallow, but extra care must be taken to prevent water damage of the explosives and detonators.

4.24 **Firing of Explosives**

There are four principal methods of initiating explosives on construction work: They are:

(a) By safety fuse and plain detonator.

(b) By safety fuse, plain detonator, detonating fuse, and the explosives.

(c) By electric detonator.

(d) By electric detonator, detonating fuse and then the explosives.

Method (d) is the safest because it allows for the detonator to be kept out of the hole and therefore readily accessible.

PART 5

SAFETY PRECAUTIONS DURING BLASTING

5.1 Defective Explosives

Explosives known to be, or suspected to be, defective are not to be used. They may cause a premature explosion or misfires and endanger people and property. These must be disposed of as set out in Part 7.

5.2 Pubic Relations

To avoid complaints it is essential that all persons within a reasonable distance are advised beforehand of what is going to take place, when it's going to take place, and what signals will be used prior to each blast and the safety precautions to be taken when this is happening. All persons should retire to a position of safety which shall be indicated by the construction blaster and they must not return until the approved all-clear signal is given by that person.

5.3 Orderliness and System

It cannot be overemphasised that successful and safe blasting can only be assured by careful attention to detail and by seeing that every operation from preparation to detonation is carried out in its proper order and correct manner.

5.4 Accessories

Ensure that the correct tools such as crimping pliers, tamping rod, fuse igniter, exploder, circuit tester, firing cable, and connecting wire are available.

5.5 System and Control of Debris

Plan beforehand a systematic work pattern so that holes can be set to a definite pattern, marked, and drilled to fixed lines. Correct tamping with an adequate quantity of good stemming material can minimise some of the fly rock. The use of millisecond delays between shots will also reduce vibrations to adjacent structures. By judicious selection of delays and placing of the holes, a considerable control of the broken rock can be obtained.

5.6 Counting of Multiple Detonations

This is only possible with safety fuse firing and shall be done by two persons, each at a different position. Unless a misfire is suspected, wait for 5 minutes before giving the all-clear to allow gases and dust to disperse or settle.

5.7 Log Book

It is advisable to keep a log book which should be of a stout note or exercise book type. In it record the date, time, location, lay-out or pattern depths, size of charges, detonators used, type of material, weather and

direction of wind, cover used and the results obtained. If any explosives or detonators are left over from the shot, this should be noted in the log book and also the action taken with the excess explosives.

5.8 Prevention of Fly Rock or Debris

It is the responsibility of the construction blaster to ensure that no undue scatter or damage to property occurs when blasting is carried out. Any cover that is used must be flexible enough to absorb the shock, contain the shattered material, and must be loosely tied down. Cover of a rigid nature, such as steel plate, is not acceptable because it can become a projectile. The following methods are acceptable ways of preventing fly rock or debris.

(a) *Small Blasts*—For one or two holes, a few sand bags or a heap of old sacks placed over the blast area with link chain netting loosely tied over them will prevent fly rock.

(b) *Larger Blasts with Vertical Holes*—An established method is to use fascines and rope nets of cordage or steel wire. Manuka scrub is ideal for making fascines, bound neatly and tightly into bundles 500 mm in diameter. The fascines are placed carefully to cover fully the whole blast area. Nets with about 150 mm mesh are placed over the fascines and anchored. Sand bags tied at the corners of the nets are acceptable. They should not be too tightly anchored as some give is necessary to prevent the blast destroying them.

(c) *Horizontal Holes*—These present greater difficulty as the rock is often thrown with considerable violence. A successful method is to hang heavy timbers 25–50 mm apart on a wire in front of the blast. The addition of a wire rope net over the timber helps. The lower edge of both timber and nets should be free.

(d) *Inside Work*—Where old foundations such as machine bases are being blasted inside a structure, bales of straw covered with a loosely tied rope net would help to smother the debris and fly rock.

(e) *Trenches*—A protective covering of mats, bags, or rubber belting must be in close contact with the ground being blasted. Especially for a blast in the bottom of a trench, in some cases sand bag barriers must be used to stop the blast funnelling along the trench.

(f) *Blasting Mats*—Besides ropes made of cordage or wire and old rubber conveyor belting, there are other useful materials. A heavy flexible mat provides the best protective covering if it can be machine lifted on and off. Old tyres either cut to segments and nested or just left whole but tied together with wire are satisfactory. Fascines or a form of box mattress made with wire netting, tightly filled with brush about 300 mm thick, is particularly suitable for foundations.

5.9 Size of Danger Area

The area to be cleared of personnel before a blast will depend on such things as:

(a) The size of the blast.

(b) The type of blast.

(c) The covering of the blast area.

(d) The direction and strength of any wind.

(e) The nature of the material to be blasted, such as steel or cast iron, which may fly a long distance. The prevention of scatter of flying debris depends on the use of mats over the charge or other precautions such as delay periods between each charge. Persons in the open without protection should be two or three times the minimum danger distance away from the blast area.

Whenever possible persons should be under adequate cover as a second line of defence for protection from any flying debris. (See appendix A.)

5.10 Vibration Damage Area

There is a long history of damage attributed to, rightly or wrongly, explosive generated vibrations. Usually complaints are received concerning damage to brickwork, fibrous plaster, glass, and roofing tiles and are often magnified.

Seismologists have proved that structural damage is due to particle velocity rather than particle displacement or acceleration. Therefore it is the speed with which the ground under the structure is moved by the passing seismic or ground waves that determines the possibility of damage.

There are two types of damage: minor being the formation of fine cracks or widening of old cracks; and major damage, being structural cracking that seriously weakens the structure.

It is recognised that structures designed and constructed to sound and acceptable engineering standards can withstand without any ill effect a vibration in excess of 0.050 m/s particle velocity.

Because of age or unknown design criteria, particle velocity must not exceed 0.050 m/s, measured at the point nearest the blast, unless a registered engineer approves, in writing, a higher particle velocity. Any approval must be based on New Zealand Standard 4403: 1976 para. 10.5. The appendix gives a guide to safe distances at which various quantities of explosives may be used without damage to sound structures.

5.11 Warning Signals

A system of warning signals should be used on construction work. For uniformity the following notice and code is suggested. Three long audible blasts at least 2 minutes before firing. Two short audible blasts for all-clear. Audible signals are no substitute for a visual check of the danger area. Most jobs have a compressor to which an air whistle or siren can be fitted, or a car horn, etc., can be used. Danger notices with the blasting signal

code should be erected on all roads and tracks leading to the blast area beyond the danger area limits. Remember that, as the operators of drills and machinery working in the area may not hear the signals, the construction blaster and safety supervisor must make a visual check that all personnel, including those in sheds, are cleared out of the danger area.

5.12 **Sentries**

Before a blast is fired, guards or sentries with red flags should be posted at all strategic points and entries to the area to prohibit any person from entering the danger area until after the blast is fired and an all-clear is given. Red flags must be at least 600 mm × 600 mm. Sentries must clearly understand their duties.

5.13 **Extraneous Electricity**

A possible danger in the use of electric detonators is premature firing from lightning or stray electric currents in the ground arising from leakage of heavy conductors or from static electricity of TV transmitter towers. Certain types of high-powered frequency-modulated radio transmitters could be a source of danger if electric detonators are used in close proximity. When detonator leg wires are stretched out about 150 mm above the ground they may provide a receiving antennae for the radio transmitted current.

In the event of emergency vehicles such as Fire Service driving into the danger area, the safety supervisor must ensure that they are kept at a safe distance from an electrically initiated firing circuit. If in doubt shut down mobile transmitters and transfer the equipment if the set is closer than 100 m to the firing circuit. However, tests have shown that under job conditions a mobile transmitter set, when operated in the normal manner, cannot fire an electric detonator. Fences or overhead power lines are possible sources of extraneous electricity on a blast site.

5.14 **Precautions Against Lightning**

(a) There is no protection against a direct lightning strike. Suspend all work and clear the area when thunder is audible since lightning as far away as 8 km, can, in some cases, fire a detonator. Under no circumstances wait to carry out any work other than to ensure that everyone is well clear of the area.

(b) Keep lead wires on detonators and firing cables shorted right up to the time of firing to avoid leakage or a circuit for induced currents.

(c) Keep both wires of firing cable and lead wires as near as possible together as a pair or twisted together so that induced currents from power lines and transmitters are neutralised.

(d) Use detonating fuse whenever possible so that the single detonator for initiation can be inserted at the last moment.

5.15 **Misfires**

With few exceptions, misfires are traceable to poor workmanship, ineptitude on the part of those preparing loading and firing of explosive charges, or

failure to adhere strictly to standards of good practice. A misfire has occurred if the number of shots known to have fired is less than the number of holes charged and connected up for firing, or there is reason to suspect any charge has failed to explode, or if unexploded explosives are found after the detonation of a charge.

5.16 **Reasons for Safety Fuse Misfires**

Common causes of delays or misfires with safety fuse are:

(a) Badly kinked fuse due to careless handling.

(b) Damp fuse due to damp storage or wet site conditions.

(c) Not clearing the detonator of foreign material, and so putting a barrier between the fuse and explosive composition.

(d) Not cutting a square end on the fuse being inserted into the detonator and so wedging an obstruction between the powder train and the explosive composition.

(e) Cutting the fuse with a blunt instrument and so sealing the powder train with ragged edges or bituminous smear.

(f) Bad crimping allowing moisture to enter.

(g) Using defective fuse or crimping tools.

(h) In wet holes, failing to waterproof with sealing compound around the junction of detonator and safety fuse.

(i) Fuse stored in hot conditions may crack and allow dampness to penetrate the powder train.

5.17 **Electric Initiation Misfires**

Common causes of misfires with electric initiation and their prevention are:

(a) Current leakage to earth from the firing cable, uninsulated joints, or bad connections. This can occur even though the exploder has sufficient capacity. Keep all joints properly insulated and use only insulated firing cables in good condition. Irrespective of the conditions, all electrical joints must be properly insulated with insulation tape or other insulating device.

(b) Faulty exploder operation. A properly maintained exploder, capable of giving the correct charge, will do so only when correctly operated. The push-down rack bar type exploder must be depressed with a smooth rapid motion with extra power put into the end of the stroke. In the case of twist exploders, when firing, give a vigorous turn with the handle as far as it will go.

(c) Damaged firing cable. The firing cable can become damaged during use, inspect it regularly for damage to the insulation or conductors. Tests should be carried out regularly for continuity and resistance.

(d) Incorrectly connected circuits. Care must be taken to keep connections separated so that no detonator is short circuited, causing a misfire. Misfires can be caused by loose or dirty connections introducing high resistance and these can be avoided by careful and systematic checking of all connections together with the testing of the circuit by the use of an ohmmeter.

5.18 **Detonating Fuse Misfires**

Detonating fuse misfires are commonly due to:

(a) Poorly made or incorrect joints.

(b) Poor contact between the detonator and the detonating fuse.

(c) Damaged or defective detonating fuse.

(d) Detonator incorrectly positioned on detonating fuse.

(e) Ends not sealed before being placed in water or wet holes for any length of time before firing.

5.19 **Treatment of Safety Fuse Misfire**

If a misfire has occurred, allow at least 30 minutes to elapse before approaching to investigate. Where a fuse has failed to ignite, relight after the usual firing procedure has been followed. Otherwise follow procedure set out in para. 5.21.

5.20 **Electric Initiation Misfire**

If a misfire has occurred, disconnect the cable, remove the key or handle from the exploder, and wait at least 5 minutes, then:

(a) All persons other than the construction blaster are to remain under cover or outside the danger area.

(b) Examine the cable and connections for any faults or wrongly made joints and remedy same.

(c) Test the circuit from the firing point using a suitable ohmmeter.

(d) If the circuit is in good order reconnect to the exploder and fire again, after all pre-firing procedures have been followed.

(e) If the circuit is incomplete or it doesn't fire again, the fault must be in the bore hole and the methods described under misfire treatment (para. 5.21) will apply.

5.21 **Detonator Misfire**

This applies to the use of plain or electric detonators initiated by safety fuse or electric current. If fired by safety fuse the construction blaster must wait at least 30 minutes or if by electric current wait 5 minutes before re-entering the blasting area, then:

(a) If safety fuse, treat as a misfire for safety fuse.

(b) If electric firing, treat as a misfire for electric firing.

(c) If the detonator has fired, examine the detonating fuse to see if it has cut off owing to over-sharp bends or because the branch lines were wrongly made. If unfired fuse is found, connect new fuse to the undamaged piece and try firing again in the normal manner.

(d) If the trouble is located in the bore hole use the methods described in misfire treatment para 5.22 below.

5.22 **Misfire Treatment**

Having located a misfire, do not attempt to drill into the charged hole but treat as set out below. Circumstances will dictate which method is the safest to use. A misfire among a number of charges may when fired cause excessive rock scatter because the successful shots have relieved the overburden. Therefore in such cases adequate cover must be used.

5.23 **Removal of Stemming and Repriming**

Where a hole has completely misfired, the stemming may be removed by applying water under pressure, or by compressed air and water, through a length of rubber or plastic hose which shall have no metal fitting within the hole. Where water under pressure, or water and air pressure, is not available, the stemming may be sludged out by the use of water and a wooden or other approved implement. On no account must compressed air alone be used.

When the stemming has been removed from a charge of nitro-glycerine explosive a fresh priming cartridge shall be inserted and the hole again stemmed and fired. Where necessary in surface operation, an artificial burden or cover shall be placed around and over the hole to prevent fly rock. In the case of a misfire containing ANFO or slurry or any other explosive rapidly destroyed by water, such explosive may be sludged out down to the primer using the procedure described for removal of stemming. The slurry explosive washed out in this manner shall be collected and burnt in a safe place. The hole shall then be reprimed and fired to explode the original primer.

5.24 **Relieving Hole—Misfire Treatment**

Where it is not possible or practicable to explode a misfire by refiring as in the previous paragraph, a relieving hole shall be drilled parallel to the original hole, then charged and exploded as follows:

(a) The collar of the misfired hole shall be effectively blocked by the insertion of a wooden plug or otherwise clearly marked.

(b) When the misfire hole is 50 mm or less in diameter and less than 3 m in length, such holes shall not be drilled closer than 600 mm to the nearest point of the misfired hole.

(c) With a larger and longer hole the distance between the misfired hole and relieving hole shall be increased as circumstances warrant with increasing diameter and length of hole, so that the misfired charge will not be drilled into.

(d) When an electric detonator is involved, the detonator wires shall be first short circuited and then tied to some permanent object

to aid in the recovery of the detonator after a relieving hole has been fired. All explosives recovered from misfired holes shall be collected and disposed of according to the provisions of this code.

5.25 **Predrilling Precautions**

No hole shall be drilled in any face till the face within the radius of 1 m from the intended hole has been cleaned and washed down and any cut-offs or butts have been thoroughly washed down and examined by two persons, and found not to contain explosives. Any butt holes shall then be plugged with a wooden plug. If examination reveals explosives therein, such cut-offs or butts shall be primed and fired, and the pre-drilling precautions above again taken.

5.26 **Shattered Ground**

If the ground around the misfire has been shattered, the relieving hole method should not be used. In this case the ground around the misfire must be carefully cleared till the explosives are uncovered. This must be done cautiously by following the wires or fuses down to the charge, removing the last few inches of cover by hand.

5.27 **Misfire Personnel**

The construction blaster must investigate and carry out the misfire treatment. He may have one experienced man to work with him, all other personnel must be kept well clear of the area.

PART 6

USE OF EXPLOSIVES

6.1 General

Explosives are a useful construction tool and they can be used in many ways. A few of the uses will be described to illustrate the safety precautions that must be taken when using explosives on construction work.

6.2 Bulled Hole

Bulling, also known as springing, chambering, or camouflet, was commonly used before the advent of rock drills and drilling machines, and is now largely out of date. Bulling is the enlarging of the base of a drilled hole to take a large charge. After the hole has been "bulled" or "rebulled", it shall be either cooled with water, or alternatively allow at least one hour to elapse before the hole is recharged. In any case the bulled hole must not be charged until the construction blaster has satisfied himself that the charge can be inserted with safety. If initiated by safety fuse at least 1 m must be used and in any case the fuse must always reach beyond the collar of the hole.

6.3 Popping

A hole is bored into the centre of the rock or boulder. The size of the boulder to be popped decides what quantity of explosives will be required. It is sound practice to start with a very small charge of a part plug of gelignite or even some short lengths of detonating fuse bound together to make a small charge. The hole must always be stemmed and tamped to the collar, irrespective of the method of firing.

6.4 Plaster Charges

Plaster shooting provides a ready means of breaking large boulders in circumstances where no drill is readily available. A charge of one or more cartridges is primed with an electric detonator and laid on the surface of the boulder. It is then covered with a shovelful of wet clay which is pressed into position by hand. It is an advantage to wet the surface of the boulder before laying the charge. When applying the clay, press it down so that it is in good contact with the boulder and the explosive. A high velocity, high strength gelatine type of explosive is most suitable for plaster shooting. In plaster shooting, the charges used are about four times those required for "pop" shooting and the following table will provide an approximate guide for different rock sizes.

Thickness	Charge
300– 460 mm (12–18″)	115 gm (4 oz)
460– 600 mm (18–24″)	170 gm (6 oz)
600– 760 mm (24–30″)	230 gm (8 oz)
760– 900 mm (30–36″)	280–340 gm (10–12 oz)
900–1070 mm (36–42″)	340–455 gm (12–16 oz)

By opposing the charge half on one side half on the other and connecting with detonating fuse that is in close contact with the boulder surface quite large boulders can be split. It is essential that the clay or other material be combed with the fingers to remove any stones or hard pieces that could be hurled with lethal violence a considerable distance. Never cover a plaster charge with solid material, such as a steel plate.

6.5 **Detonating Fuse Uses**

Detonating fuse has many uses both as an initiator and as an explosive.

(a) *Trimming*—Where concrete walls, foundations or small thicknesses of rock need trimming, a series of small diameter holes 75 to 100 mm apart loaded with five or six strands of detonating fuse will cut a neat line.

(b) *Concrete Pipes*—These can be cut to any length or angle by winding a number of strands of detonating fuse tightly around the pipe in two or three layers. The number of turns depends on the age, thickness, and strength of the concrete and as a general guide one turn is needed for each 300 mm of diameter. Never use explosive on concrete pipes that show cracks as the split will carry along these cracks. Similarly circular holes for side entry can be cut using several strands of detonating fuse.

(c) *Agitator Bowls*—Agitator bowls of concrete delivery trucks can have the residue of hard concrete within the bowl removed by drilling a series of small diameter holes into the build up, into which detonating fuse can be fed. The strands of detonating fuse should all be connected and detonated simultaneously. Cover should be provided at each outlet to the bowl to ensure that no fly rock occurs. This will also help to lessen the noise. This is a specialist application and only a fully experienced construction blaster must carry out the work.

Detonating fuse has a serious drawback in that it is very noisy when initiated. This can be reduced by either using a lesser grained detonating fuse or by covering it with sand, that does not contain potential projectiles or stones, to a depth of at least 150 mm.

6.6 **Demolitions**

Explosives may be used to demolish a wide variety of materials such as stone, brickwork, concrete and timber. Steel plate is difficult to demolish with explosives as it usually requires special techniques and is therefore not generally recommended.

Reinforcing steel and steel water pipes can be cut with explosives but this is specialist application using specialist explosives, such as sheet explosives which have the necessary VOD to carry out this work successfully.

6.7 **Demolition Plaster Charges**

These can be used on masonry and brickwork up to about 350 mm thick. Plaster charges are very noisy, especially in confined places or areas and

require more explosives than bore hole charges. They must be placed in direct contact with the material to be demolished and covered with clay, mud, sandbags, or earth to confine the explosion and increase its effectiveness. If there is any chance of material flying then sandbagging or other effective methods of preventing fly rock are required.

6.8 **Bore Hole Demolition Charges**

These are used on thicker walls and while making less noise and using less explosives, they do take more time to prepare. The charge must always be stemmed and tamped and suitable protection against fly rock given by using blasting mats or other cover to each side of the wall. By drilling at an angle of about 45 degrees a hole is obtained which allows the explosive to be placed in the best position and gives room for stemming and tamping. The number of rows of holes depends on the thickness of the wall. Better results are obtained by having the holes staggered. For thick walls, say over 1 m or more, three rows of staggered holes should be used. If it is possible, drilling and loading from both sides gives an improved result.

In demolition of reinforced concrete a lot of concrete is broken and crushed but retained by the reinforcing steel and after loosening and picking out the reinforcing can be cut. Extreme care must be taken to ensure that the person carrying out the cutting is not in any danger from the collapsing wall or structure. Again it is imperative that every precaution be taken to prevent fly rock.

6.9 **Demolition of Steel**

Steel girders, sections and rails can be cut by plaster charges. Steel is such a resilient material it is most difficult to obtain a clean cut. Steel, when cut with explosives, can fly a considerable distance and all persons and property must be well protected. Steel can be prevented from flying by the use of sufficient sandbags or covering with other acceptable material.

6.10 **Demolition of Timber Piles**

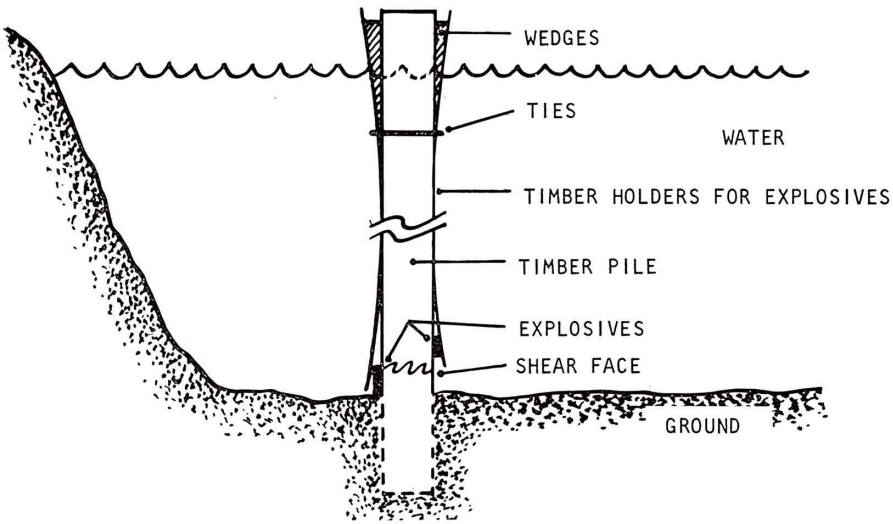
In the dismantling or demolition of timber pile bridges or wharves, the piles can be cut off below water level, even at bed level or below it by suitable charges using one of the following methods:

(a) Make up a charge in the form of a girdle of cartridges in a waterproof container, long enough to reach right round the pile. To initiate the charges two strands of detonating fuse should be taped to the cartridges and be long enough to extend at least $\frac{1}{2}$ m above the water. It is essential that the girdle of explosives fits snugly and in close contact with the pile in the firing position.

The girdle can be slipped down to the desired depth using wooden poles or some other non-conductive material. When the charge is in position make the detonating fuse fast to the top, tape a detonator to the detonating fuse about 75 mm in from the end. If the pile is to be salvaged then, before initiation, secure an anchor rope to it. Always ensure that sufficient slack is left to take up the initial shock movement.

(b) Another method of cutting a pile is to place the charge on opposite sides of the pile one above the other in order to get a shearing effect. This can be done by making two explosive bats using two lengths of 50 mm by 12 mm timber and nailing a piece of 100 mm by 12 mm at one end of each. The explosive primed with detonating fuse is attached to each 100 mm by 12 mm piece and, as in the girdle method, the explosive must be waterproofed with either polythene or some other flexible type container. The first bat is lowered down the pile and nailed into place with the explosive in close contact with the pile and with the top of the charge just below the line where the cut is to be made.

The second bat is similarly lowered on the opposite side of the pile and nailed in position, with the bottom of the charge just above the line to be cut, the two charges are then fired simultaneously. When explosives are used to cut timber the quality and type of explosive required will depend on the age, state and type of timber. A trial blast should be carried out to ascertain the quantity required. Never permit any person to be in the water within close proximity of the blast when the blast is initiated. (See also N.Z.S. 4403, Appendix E.)



SET-UP FOR CUTTING WOODEN PILE UNDER-WATER

6.11 **Stump Removal**

Tree stumps can be removed by explosives, in some circumstances it may be of assistance if the tree is still standing, as it may add leverage once movement from the blast begins. An explosive that gives a heaving force is

best suited for this work, one having a velocity of detonation of about 2–3000 m/s should be ideal such as ANFO in bag or cartridge form.

Pieces of wood may become detached from the stump when blasted, therefore precautions must be taken to ensure that damage to persons or property does not occur.

WHEN LOADING A SMALL LATERAL ROOTED STUMP THE CHARGE SHOULD BE PLACED WELL DOWN

FOR SEMI-TAP ROOTED STUMPS PLACE CHARGES UNDER EACH SUBSTANTIAL ROOT

FOR TAP-ROOTED STUMPS EITHER DRILL INTO ROOT AND PLACE THE EXPLOSIVES IN IT . . .

. . . OR PLACE THE EXPLOSIVE ON EACH SIDE OF THE ROOT AS SHOWN.

SUGGESTED METHODS FOR REMOVING STUMPS

6.12 **Line Drilling**

Can be used for a variety of purposes but its main use is to ensure a neat, clean break in rock excavations. Its use ensures that the rock outside the line drilling is left without overbreak and in a sound and unshattered condition. The use of very short delay blasting techniques has considerably simplified and improved the results. Good results are obtained by drilling or boring closely spaced holes along the exact line of the perimeter of the excavation, including one at the apex of every direction change. If the excavation is to have a sloping batter, the holes must be drilled on the exact line of the batter. If the holes are not drilled in the same plane the results will be poor. Line drill holes are generally 30–35 mm in diameter and are spaced from 2–4 times the hole diameter apart along the excavation line.

Holes larger than 75 mm are seldom used in line drilling since the higher drilling cost is not offset by increased efficiency. In practice every fourth or fifth hole in the line is loaded with a moderate explosive charge. This will depend on the rock type being blasted. The holes in between are left empty. Deck loading by placing half the charge in the bottom of the hole and the remainder at various levels up the hole to within one-third of the top will give good results. When linked with detonating fuse and fired simultaneously, the line drilling acts like the perforation on a postage stamp and a crack is made joining each hole.

6.13 **Pre-splitting**

Pre-splitting is another method of achieving smooth wall blasting and it consists of creating a line of shear in solid rock on the desired line of the break for the finished excavation.

One of the main points of difference between pre-splitting and other types of smooth wall blasting is that the pre-splitting is carried out before any production blasting and in some cases even before production drilling.

Generally holes 50 mm to 100 mm in diameter are drilled 450–950 mm apart and loaded with cartridges or part-cartridges taped to detonating fuse down-lines, with a slightly increased charge at the bottom to help to break the "toe". Experience indicates that a suitable charge ratio will be between 8.07 and 13.42 grams per square metre of area to be pre-split.

It is essential that the holes be completely back-filled and gentle shaking of the detonating fuse line as fine dry cuttings or sand are poured in will usually achieve this. It is preferable that all holes in the pre-split line should be fired simultaneously although groups may be fired using millisecond delays if required. For pre-splitting, explosives with a high VOD should be used.

6.14 **Ditch Blasting**

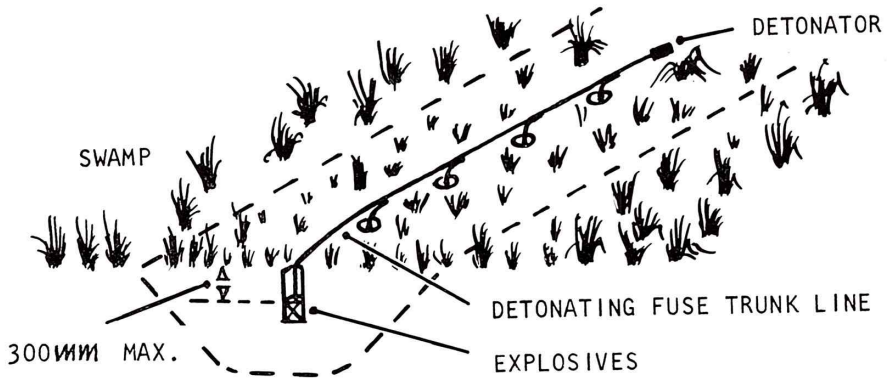
Ditch blasting in its simplest form can be carried out by detonating a single line of charges placed along the centre line of the proposed ditch or channel. Generally the most effective ditch blasting is carried out in wet or swampy ground.

For single line ditching, charges are placed in holes in the mud or silt at regular intervals. For a ditch of approximately 2 m wide at the top and 1 m wide at the bottom and 1 m deep, the charges should be spaced at approximately 500 mm apart with the top of the charge between 150 mm and 300 mm below the water or ground surface. a good rule to follow is that the harder the ground the further down from the top of the charge must be, but never more than 200 mm below the surface.

If there is a mat of ground cover, such as swamp grass or shrubs, then a rope of several strands of detonating fuse should be used to connect the charges (trunk line) then tramp the "rope" into the cover, this will open up a cut that will permit the erupting material to clear the trench.

The danger associated with ditch blasting is that when the charges go off it is possible that rocks or solid pieces of timber may be projected into the air causing danger to people or property, therefore ensure that all personnel are kept well clear from the blast area.

Precautions must be taken to ensure that water does not enter the explosive charge or the exposed ends of the detonating fuse.



SINGLE LINE DITCH BLASTING

6.15 **Demolition of Machinery Foundations**

Usually the demolition of machine foundations presents a construction blaster with the challenge of ensuring that the demolition is carried out safely and speedily. By drilling more than the usual number of holes in the block and charging each hole with a small quantity of explosives, then initiating with very short delay periods between each charge, the resultant explosion will be small in comparison to one instantaneous initiation. Cover must be more than adequate, for, as well as containing all the fly rock, the cover must

reduce the air shock wave to an acceptable level. If the demolition is within an existing structure, doors and windows should be fully opened to permit ready dispersal of the air borne shockwave.

6.16 **Demolition of Structures**

Structures such as bridges, tank towers, chimneys and so on can safely be demolished if a construction blaster carefully plans the whole operation. It is of little use placing a number of charges around a structure and initiating, hoping that sufficient movement will result to topple it. Often the result is merely a reduction in height or an unstable structure left hanging.

Start the structure falling in the direction you want it to go, by initiating that side first, and, once it is moving, complete the demolition. Delay firing techniques are most suitable for this type of work.

PART 7

STORAGE AND DESTRUCTION OF EXPLOSIVES

7.1 Introduction

Because explosives are perishable, have a limited life span, and are designed to explode, precautions must be taken in the interests of safety to ensure that they are correctly stored. Thus, at all times, proper and secure storage of explosives, detonators, and explosive accessories is necessary to ensure that they are kept out of unauthorised hands, to avoid accidental explosions and to maintain them in a sound, safe condition.

7.2 Types of Storage

Separate types of storage are required as follows:

(a) Main magazines, in which shall be stored all commercial explosives, blasting powder, detonating fuse, and boosters or primers which are not classed as detonators.

(b) Detonator magazines, in which shall be stored only detonators and detonating relays, except that provision may be made in a detonator magazine for the suitable storage of capped fuses.

7.3 Storage of Explosives

Storage of explosives on construction work is subject to the requirements of the Explosives Act 1959 and the granting of a magazine licence by the Chief Inspector of Explosives. Exemptions from the requirement of licence to store explosives are as follows:

Of any explosive other than gunpowder not more than 2.5 kg together but stored separately with not more than 100 detonators. Only sufficient quantities of explosives and detonators for daily use shall be brought to the immediate vicinity of the blasting operation. Temporary storage may be required. Temporary storage is daily storage and, unless the explosives are stored in a licensed magazine, must be limited to that period only.

7.4 Suitable Temporary Storage

Suitable temporary storage may be a shelter of galvanised iron with a raised wooden floor and lined with timber. The external cladding shall be not less than 1 mm galvanised iron. The door is to open outwards and should have a night latch (deadlock type). Adequate ventilation is necessary, subject to preservation of security and fire resistance, to ensure that condensation or high humidity within such structures does not cause deterioration of the explosives. A detonator receptacle may be a strong wooden box of at least 25 mm-thick close-jointed timber giving an inside measurement of approximately 600 mm × 600 mm × 600 mm and free of exposed iron or steel. It may be bolted to the floor in the shelter. The door must open outwards and should have a stout lock with a key different from that used for the outer door.

If the shelter cannot be anchored down, it should be weighted so that it is too heavy for four men to lift. This would be suitable for quantities of up to 50 kg. Quantities of over 50 kg must be housed in a magazine in a dry place preferably on slightly sloping ground. The floor should be at least 150 mm above the ground, and if several tonnes are to be handled it is better to have it at truck deck height. The floor should be large enough to:

(a) Provide a convenient working space to facilitate stacking or handling the cases in the magazine.

(b) Separate consignments by date and time.

(c) Allow ready inspection of cases in their stacks.

(d) Stack no more than seven cases high as an allowable maximum. At least $2\frac{1}{2}$ m^2 floor space should be allowed for each tonne of explosives. Sleepers or duckboards should be used to keep the cases off the floor, and stacks should be away from the walls; this allows for free air circulation to help maintain an even storage temperature. Separate storage for detonators, relays, etc., can be provided as for quantities of explosives under 50 kg.

7.5 **Site Use and Danger Distances**

As a guide to the temporary holding of explosives on the site in the course of day-to-day operations, the following minimum distances must be observed for separation between explosives and occupied buildings or pedestrian walkways.

Serious Danger Distances Due to Air Blast Effects

2.5 kg	42 m
5 kg	55 m
10 kg	67 m
15 kg	76 m
20 kg	85 m
25 kg	120 m

These danger distances may be reduced down to one-half if there is additional protection from the blast by way of artificial mounds or natural barricades, or by the lie of the land.

7.6 **Rotation of Stocks**

To ensure that all explosives are used while in good condition, stocks should be used in sequence of date manufacture. The outer package of any container in which explosives are packed must show the date of manufacture. Once a package is opened it should be used as soon as possible. If all explosives are not used at the same time then the original wrappings and package should be refolded to seal in the explosives and the case should be closed in order to give maximum protection to the contents. Loose quantities must be held in sealed plastic bags.

7.7 **Record of Stock**

The person in charge of each magazine shall keep a stock book showing the quantities of explosives on hand and the quantities, dates, and time at which they were received or issued, and the names of the person issuing and receiving. A physical stock check should be made periodically. To assist with stock checking all stacking of explosives in magazines should be with the cases or cartons stacked with the manufacture date to the outside.

7.8 **Magazine Surroundings**

The surroundings of a magazine or storage place must be clean and orderly and all inflammable materials such as leaves, dry grass, brush, rubbish, and refuse must be kept clear. It is recommended that at least 10–12 m be kept clear around each magazine.

7.9 **Magazine Interior**

The interior of a magazine must be kept scrupulously clean and free from grit. A broom should be kept at the entrance for sweeping. The floor must be inspected and if necessary swept every time explosives are received into the magazine or delivered out of it or when the magazine is entered for any purpose whatsoever.

7.10 **Magazine Conduct**

Where walk-in magazines are used on construction work the following rules will apply:

(a) *Access to magazines*—No person under the age of 18 years shall be permitted to enter a magazine. Persons over 18 years but under 21 years of age may enter a magazine only if they are certificated persons or are in the presence of and under the direct supervision of the person in charge of the magazine.

(b) *Magazine shoes*—Unless otherwise approved, no person shall enter the magazine unless he is wearing shoes constructed without any external iron or steel in the soles or heels. Shoes shall be cleaned before entering or alternatively clean overshoes or galoshes shall be worn. For such purpose overshoes or galoshes shall be provided by the employer in the magazine adjacent to the door.

(c) *Lighting*—No naked light shall be permitted in the magazine. Any portable lights or permanent lighting installations must be approved by the Chief Inspector of Explosives.

(d) *Precautions in thunder storm*—On the approach of a thunder storm, the magazine shall be closed and all persons shall be withdrawn to a safe distance until the storm has passed.

(e) *Magazine equipment*—Only approved articles supplied by the employer shall be taken into or permitted to remain in the magazine. They are: wooden mallet, wooden wedge, broom, and magazine shoes.

(f) *Smoking*—No person shall smoke in or within 15 m of a magazine, and no smoking requisites shall be taken into a magazine.

(g) *Intoxicated persons*—No intoxicated person or persons under the influence of drugs or intoxicating liquor shall be permitted to enter or remain in the magazine, and no intoxicating liquor shall be taken into the magazine.

(h) *Maintenance of magazines*—Magazines shall be maintained in good order and in a weatherproof condition. Explosives shall be removed from the magazine before repairs are carried out.

(i) *Security of magazine*—The employer shall be responsible for the security of the magazine and, except when explosives are being removed or placed in the magazine, the magazine shall remain locked at all times.

7.11 Detonator Storage

Where possible detonators and explosives should be stored separately.

If detonators are to be stored with explosives, an intervening partition or space which will effectively prevent an explosion or fire in one compartment spreading to the contents of the other compartment must be provided. If this cannot be done then a separate storage magazine or receptacle located at least 5 m away must be used. The receptacle or store house must be strongly constructed of timber, or, if metal is used, be lined with timber or hardboard. It must be moisture-tight and securely locked to prevent theft of the detonators.

7.12 Safety Fuse Storage

Safety fuse must be stored in a dry, clean place where it will not be damaged and is inaccessible to children and will not be subjected to extremes of temperature.

7.13 Left Over or Unused or Unwanted Explosives

At the end of each day all explosives that remain unused must be returned to the magazine or taken from the site and locked up in separate containers, one for the detonators the other for the explosives.

7.14 Destruction of Blasting Materials

From time to time surplus or defective explosives have to be destroyed. Where large quantities have to be destroyed, the Chief Inspector of Explosives should be informed and he will give instructions concerning their disposal. For small quantities the following paragraphs are a guide to cover the examination and disposal of explosives and detonators.

7.15 Signs of Defective High Explosives

Visual examination is usually sufficient to determine whether the explosives are fit for use or should be destroyed.

Deterioration—Nitro-glycerine in gelatine explosives tends to darken with age. This effect is accentuated at the end of the cartridge where moisture may

be observed and is shown by softening of the contents and darkening of the ends of cartridges. In bad cases it becomes a glutinous mess. It may be accompanied by exudations of nitro-glycerine. Excessive moisture penetration leads to the appearance of an aqueous salt solution. This can usually be distinguished from nitro-glycerine by placing in some clear water. If oily globules like clotted cream separate out nitro-glycerine is present. If free nitro-glycerine is present an expert must be consulted before the explosive is moved. If movement cannot be avoided, the liquid, whether nitro-glycerine or aqueous solution, should be carefully absorbed in plenty of dry sawdust and care taken to avoid friction or shock during handling. When moisture contamination has occurred and redried, incrustation of crystalised salt may be present. Bad contamination will require the destruction of the explosive. Nitro-glycerine powder explosives also darken with age and will absorb moisture, especially at the ends of the cartridge. The deterioration is more rapid than with gelatine explosives.

7.16 **Disposal by Burning**

To dispose of up to 5 kg of explosives the following methods shall be strictly adhered to. Select a flat, open piece of ground, as far as possible free from stones or other potential projectiles, well away from roads and buildings, so that in the event of detonation of the explosives there is sufficient isolation to avoid damage. The person destroying the explosive shall make sure that he has an unobstructed route to a place of safety from which he can observe the burning. Where necessary, guards shall be placed to ensure that no person has access to the disposal area while burning is in progress.

A train of combustible material at least 100 mm wide and at least 50 mm in depth shall be laid so as to point into wind, and the cartridges of explosives shall be checked to see that they contain no detonators before they are laid on the train of material. Cartridges shall be placed on the train no more than two abreast leaving space of at least 2 m between the down-wind end of the train and the first explosive cartridges. The explosives and the combustible material shall be saturated with diesel oil or kerosene, **but not petrol,** and the down-wind end of the train lit. It is most important for the train of combustible material to burn against the wind. The operator shall retire to a place of safety immediately the train is burning.

When burning has definitely finished, wait for 15 minutes before approaching the site of burning.

He shall make sure, by raking the ground with a wooden rake, that no unburnt or partly burnt explosives remain on the train and that no explosive has been scattered. These, if found must be collected and burned on another train. If it is necessary to lay another train, it should be laid at least 5 m from the site of any previous train to avoid the hot ground from the previous train.

No person shall make or permit to remain alight any fire in the open air except in accordance with the provisions of clause 3.2 of N.Z.S. 9231 : 1971 Model Bylaw for Fire Prevention.

7.17 **Disposal by Dissolving in Water**

Small quantities of blasting powder may be destroyed by placing it in buckets or drums of water and subsequent burning of the oil. ANFO should not be placed in running water because of the dangers of oil pollution.

7.18 **Disposal of Detonators**

Quantities of detonators from 15 to 100 shall be tied round a primer consisting of about 30 grams of explosive and a good detonator. Smaller quantities of detonators may be disposed of by a single good detonator. Electric detonators for disposal shall have the lead wires cut off about 10 mm from the top of the tube. A hole at least 300 mm deep shall be dug in stone free ground, preferably dry sand, the detonators buried in the hole and covered with stone free earth or similar material. The detonator shall be fired from a safe location and, after the explosion, a search shall be made of the hole and surroundings for unfired detonators.

7.19 **Safety Fuse Destruction**

Safety fuse which has deteriorated in any way, or is suspect for any reason, is destroyed by burning it on a bonfire built on open ground in a safe place.

7.20 **Detonating Fuse Destruction**

If detonating fuse has to be destroyed it should be done by burning as for high explosives. Always unroll it in two parallel lines approximately 15 mm apart and place it on a combustible train.

7.21 **Explosive Containers and Wrappers Disposal**

All empty packages, box liners, packing, wrappers, and empty bags which are contaminated must be destroyed by burning in a clear open space.

PART 8

LEGISLATIVE REQUIREMENTS

8.1 General

This section sets out the present law on the subject of blasting on construction work and also the certification of construction blasters and safety supervisors.

8.2 Statutes Applicable to the Use of Explosives on Construction Work

(a) The Construction Act 1959 and the Construction Regulations 1961, administered by the Chief Safety Engineer, Department of Labour.

(b) The Explosives Act 1957 and the Explosives Regulations 1959, administered by the Chief Inspector of Explosives.

(c) The Police Offences Act 1927, administered by the Police Department.

(d) Local authority bylaw, administered by the local authority concerned.

NOTE: The Quarries Act 1944, the Quarries Regulations 1959, and the various Mining Acts do not apply to work that comes under the Construction Act.

8.3 Explosives Act

The Explosives Act and regulations have general application dealing with the authorisation and importation, manufacture, sale, storage, carriage, packing, marking, and holding of explosives. This Act and its regulations affect construction employers regarding storage and transport of explosives exceeding 400 kg on construction work. Temporary storage of one day duration only, and transport on the construction site comes under the Construction Act.

8.4 Police Offences Act 1927

Regulations (bb) and (cc) can affect construction work because it is an offence to "blast any rock, stone, or timber in or near any public place without permission of the loca authority, or not attend to any directions in regard thereto given by such local authority; or to set off any fireworks or explosive material in or on any public place, or so near there as to endanger, annoy, or frighten the passer by".

8.5 Local Authority Bylaws

Irrespective of the Construction Act and the Police Offences Act a person using explosives on construction work must advise the local authority controlling the area where the work is to be done and if there are any bylaws they must be complied with.

8.6 Construction Blasters Code A B C for Safety

(A) Always work to a methodical plan.

(B) Blasting mats prevent fly rock and damage.

(C) Control every aspect of the blasting operation.

(D) Delay detonators and delay detonating relays reduce shock and fly rock, and improve the blast.

(E) Electric initiation of explosives eliminates the loss of control inherent in safety fuse firing.

(F) Fire your charge only when all safety precautions have been observed.

(G) Good stemming material well tamped improves the result of the blast.

(H) Holes must be clear of all obstructions before charging begins.

(I) Inspect all circuits before connecting the firing cable at the charge end.

(J) Judge each action carefully.

(K) Keep up to date with new developments.

(L) Learn and know your safety precautions.

(M) Misfires are generally caused by poor workmanship.

(N) No charge is complete without proper fly rock prevention.

(O) Only one competent and certificated person must be in charge of preparations for firing and of the actual firing.

(P) Proper and secure storage is necessary at all times for explosives, detonators, and fuse.

(Q) Questions on the use of explosives can best be answered by the manufacturer's technical representative.

(R) Remember to tell the local authority and the public when and where you are going to blast.

(S) Smoking is prohibited when handling or working with explosives.

(T) Tidiness in your work reduces the possibilities of accidents.

(U) Use the oldest explosives first if they are in a sound condition.

(V) Various accessories are available, choose the correct ones for your particular work.

(W) Wait until fumes clear before returning to any successfully detonated blast site.

(X) X is the unknown factor you must guard against.

(Y) Your methods of work will influence those you teach by example, always be safe.

(Z) Zero is the time you fire your blast and is always after the danger area has been cleared and every precaution taken.

APPENDIX

BLASTING QUANTITY VERSUS DISTANCE TABLE

(NZS 4403 : 1976)

(a) This table sets out the maximum quantity of explosives per shot for instantaneous firing or per each separate delay detonator for a metric scaled distance of 25 in accordance with clause 10.5.6.2 (a) of the Explosives Code (NZS 4403:1976—The Storage, Handling, and Use of Explosives).

(b) For a scale distance of 25 the particle velocity will be less than 0.050 m/s (1.97 inches per second).

(c) Except as provided in clause 10.5.4.2 blasting in the vicinity of structures shall not exceed 0.050 m/s.

(d) The weight in kilograms for a distance D in metres for a metric scaled distance of 25 is:

$$W \text{ max} = \frac{D^2}{625} \text{ kg}$$

(e) NZS 4403 gives conservative results for scale distance as compared to the U.S. Bureau of Mines scale distances which were generally used prior to the issue of NZS 4403. The relationship is as follows: U.S. Bureau of Mines (imperial) scale distance × 0.45 = NZS 4403 metric scale distance.

The following table gives the safe distance at which various amounts of explosive may be used without damage to sound structures. It is possible to blast safely at closer distances than this but to do so requires the use of special instruments. (See NZS 4403 : 1976.)

Distance D from blast area to nearest building or structure		*Maximum quantity of explosive per shot for instantaneous firing as per each separate delay detonator*	
Metres	Feet	Kg	lbs
1.5	5	0.00	0.01
3.0	10	0.01	0.03
4.6	15	0 03	0.07
6.1	20	0.06	0.13
7.6	25	0.09	0.20
9.1	30	0.13	0.30
10.7	35	0.18	0.40
12.2	40	0.24	0.52
13.7	45	0.30	0.66
15.2	50	0 37	0.82
18.3	60	0.54	1.18
21.3	70	0.73	1.61
24.4	80	0.95	2.10
27.4	90	1.20	2.66
30.5	100	1.49	3.28

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